POWER PLANT ENGINEERING

Established Over 32 Years

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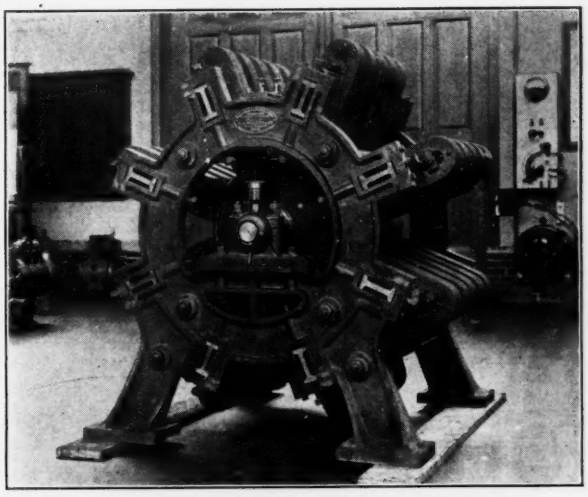


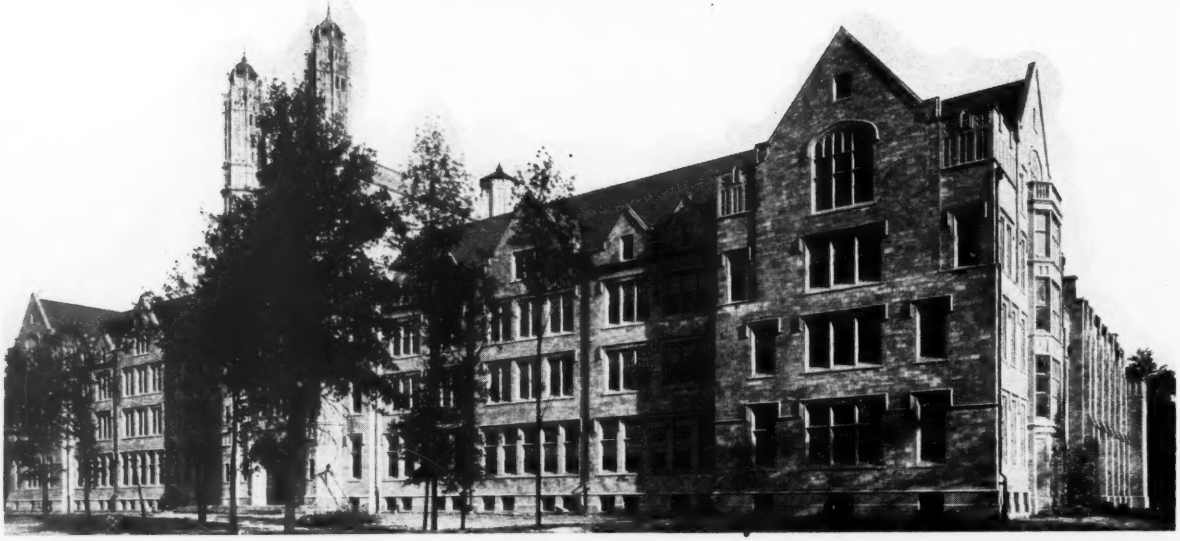
Horses! Horses! Horses!

WELL MIGHT the designer of the mammoth 4-kw. dynamo shown above have waltzed around, wringing his hands, singing the then popular version of our modern "Horses! Horses! Horses! Crazy over Horses!" if he had dreamed that his machine was to be the grandfather of the puny 100,000 and 200,000-kw. units now being built.

In fact, his contemporaries would probably have thought he had the D. T.'s or that reactive component Mr. Johnson discusses so glibly on page 298 was chasing him around in the guise of a pink elephant. (The reactive component even today is accused of queer doings.)

The 4-kw., 40-v., 100-amp. machine, approximately 6 ft. diam., was built in 1881 by A. De Meritens Co. of Paris and was in continuous service until October 10, 1924, in connection with a lighthouse arc light. It is now in the Polyteknisk Lareanstal, Copenhagen, Denmark. The photograph was taken by Prof. El. Bache and presented to Prof. B. R. Vanleer, now in Europe as one of the A. S. M. E. selections of the John R. Freeman Travel Scholarship Fund.

Even our good friend, Baron Munchausen, the dean of advertising men, never dreamed of squeezing 150,000 horses into one good sized transport wagon. Verily, the boys in that age were good but they lacked imagination. What a chance for a statistician! If all the hairs from the tails of all the horses represented by a modern turbo-generator were placed end to end, even our imagination, trained as it is in visualizing the invisible, fails to register the resultant distance.



Marygrove College Installs Una-flow Engines

BEAUTIFUL BUILDINGS OF NEW COLLEGE FOR WOMEN AT DETROIT, MICH., ARE SERVED WITH POWER, LIGHT AND HEAT BY ATTRACTIVE POWER PLANT INCLUDING TWO ENGINES OF 400 KV.A. EACH

ON THE OUTSKIRTS of Detroit, Mich., within easy reach of the attractive residential districts to the west and northwest of the city, Marygrove College, a private college for girls, has recently erected a group of buildings that is considered one of the most beautiful educational groups in the country. The college was founded and is conducted by the Sisters Servants of the Immaculate Heart of Mary. The present enrollment is 300 students and the plant is planned for 750 students.

There are two main buildings at present of the general architectural style shown in the headpiece, located near 6-mi. Road and Wyoming, Detroit. These buildings contain class-rooms, offices, laboratories and living quarters for the students. These are attractively set in spacious grounds, with a residence for the president between them. Beautiful landscaping of the grounds to preserve the natural characteristics and the groves of trees and to give long, winding driveways, makes this an ideal setting for an institution of learning.

The three present buildings of the college are supplied with power, light and steam by a compact and well-arranged power plant shown in the illustrations. In one end of the power plant building, entirely separated by a partition, a completely equipped laundry has been installed to care for the students' linens and the tableware and other things used by the school. There is, of course, the usual heating load, carried by a steam system and in addition a large amount of steam as well as electric power is used for cooking. Then, too, the heating and ventilating system of the building is of the most modern type, the ventilating fans and refrigerating equipment requiring electric power. Since it is expected that summer courses will be conducted at Marygrove College, it can be seen that the laundry and cooking and power loads will be fairly constant throughout the year. For this reason, it was felt that the exhaust steam and process steam demands justified the installation of a power plant which could supply exhaust steam for these purposes and generate power as a .by-product very cheaply.

TWO UNA-FLOW ENGINES SUPPLY POWER AND EXHAUST STEAM

Of special interest in this power plant is the installation of two Ames four-cylinder vertical Una-flow steam engines for generating power and supplying exhaust for the purposes noted above. Each engine has four 13-in. by 14-in. cylinders, taking dry saturated steam at the throttle at 150 lb. gage pressure and exhausting at 6 lb. gage. One of these engines is shown in the accompanying illustration, the second unit being set beside it. Each engine drives a 400-kv.a. Crocker-Wheeler a.c. generator at 300 r.p.m.. Power is generated at 2300 v., 3 phase, 60 cycle. To each main engine shaft, outboard of the generator, is connected a belt-driven Crocker-Wheeler 10.5-kw., 125-v. exciter driven at 1325 r.p.m.

Steam and exhaust piping connections are as shown on Fig. 1. Space is allowed in the engine room for installation of another similar unit when required and the entire arrangement is simple and compact. The engine room is attractively finished in cream brick, of which the power house is constructed throughout; it is well lighted from two sides and presents an attractive appearance. A Whiting 4000-lb. hand-operated crane runs overhead, the length of the engine room, for handling engine parts. Each engine is equipped with a Richardson-Phenix force feed lubricator for cylinder lubrication, the other engine parts being lubricated by a pressure system built into the engine. Lonergan and Ameri-

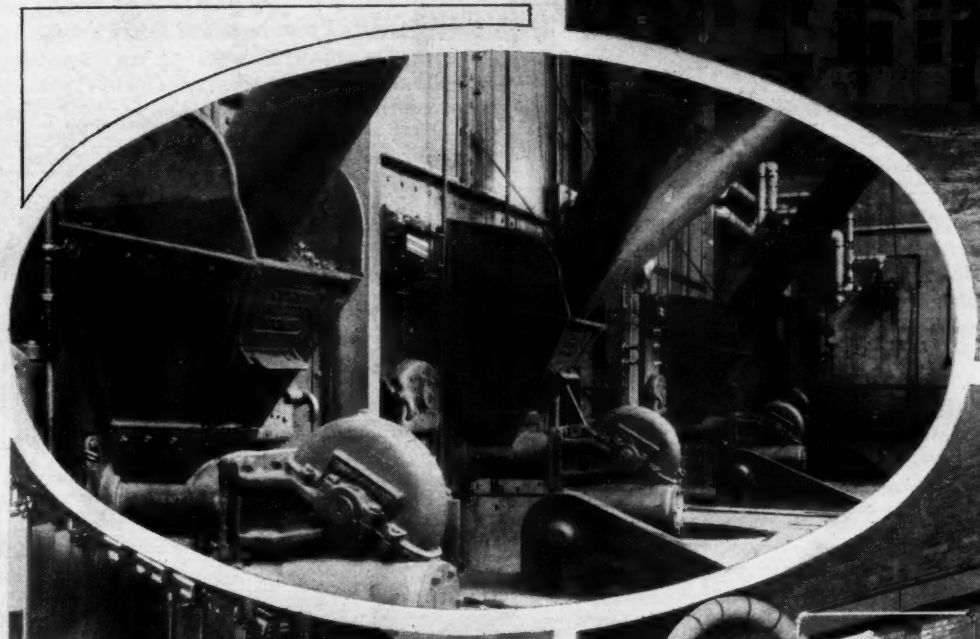
Views of Principal Equipment in New Plant at Marygrove College

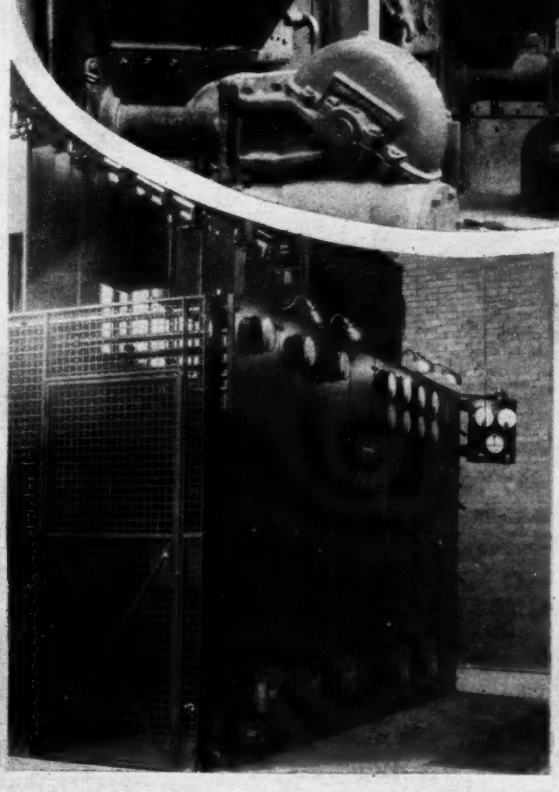
Right—Plant built of cream brick has pleasant setting in grove.

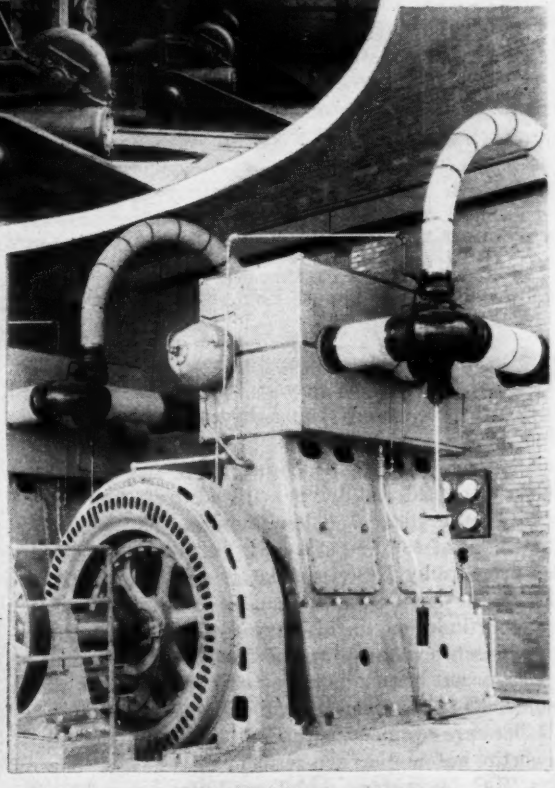
Oval—Three 250-hp. boilers are fired by single retort underfeed stokers.

Lower left—Power circuits to buildings are controlled by this switchboard.

Lower right—Two 400-kv.a. vertical uniflow engines supply power and exhaust steam.







can Schaefer & Budenberg gages for both units are mounted on a wall panel behind the units.

Electric power is controlled by a Westinghouse switchboard in the engine room, as shown. This carries the necessary oil switches, rheostats, meters and voltage regulator. Power is transmitted through underground conduits to the various buildings and is there stepped down from 2300 v. to 220 v. for the building circuits by banks of Kuhlman transformers of suitable sizes ranging from 10 to 50 kv.a.

Stoker-Fired Boilers Supply Saturated Steam

Steam is generated at 150 lb. gage pressure by three Ladd water-tube boilers of the vertical three-drum type, Fig. 1, each rated at 250 boiler horsepower. These make dry saturated steam, no superheaters being installed. Each boiler is fired by a Detroit, single-retort underfeed stoker, the three stokers being driven from a line shaft taking power from a 7-in. by 6-in. Engberg vertical steam engine. This engine, Fig. 3, has a maximum speed of 325 r.p.m., and also drives a forced draft fan supplying air to the stokers. This fan is a Clarage No. 80 unit. Speed of fan and stokers is regulated to maintain steam pressure by Mason regulators and a Gardner governor on the engine steam line. A McCord lubricator supplies cylinder oil to this engine. This unit at atmospheric pressure exhausts to the feedwater heater. Flue gas passes out through a Custodis radial hollow tile chimney, 12 ft. in diameter and 150 ft. high.

Boilers are equipped with Consolidated safety valves, Walworth automatic non-return valves and blowoff valves, S-C feedwater regulators, Vulcan soot blowers, Walworth gate and globe valves and various Boylston and Lunkenheimer valves on steam and water lines. Reliance water columns with inclined gages, American Schaefer & Budenberg pressure gages and Ellison draft gages furnish the boiler operators with information of furnace and boiler conditions. National pipe is used on steam and water lines, covered with Johns-Manville insulation. Boylston high pressure steam traps and pressure reducing valves and Webster low pressure heavy duty traps are used at suitable points as shown on Fig. 1.

Elevators Handle Coal and Ash

Coal, delivered to the plant by motor truck, is dumped into a hopper feeding a Link-Belt bucket elevator. This elevates it to two cast-iron storage bunkers above the boilers as shown; these are cylindrical cast-iron bunkers of 50-t. capacity each, furnished by Combustion Engineering Corp. From these coal is spouted direct to the stoker hoppers below. Coal weights are obtained by weighing in the delivery trucks.

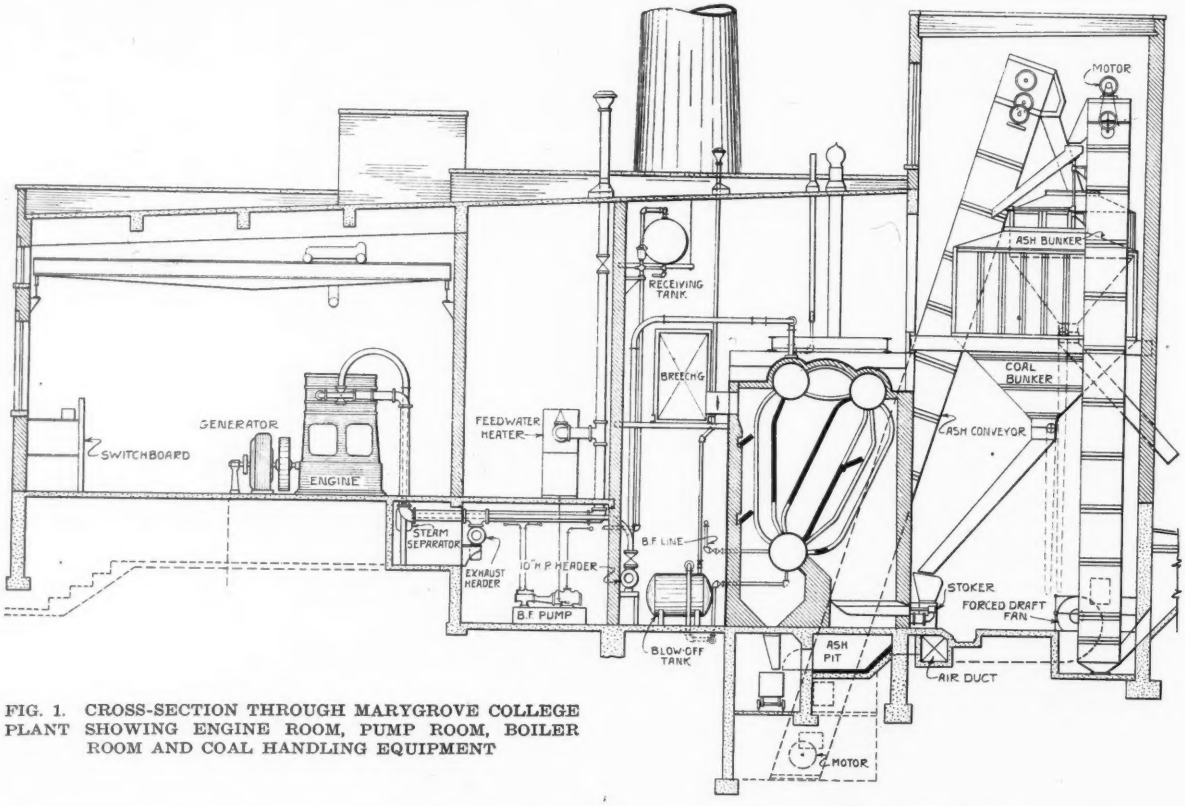


FIG. 1. CROSS-SECTION THROUGH MARYGROVE COLLEGE PLANT SHOWING ENGINE ROOM, PUMP ROOM, BOILER ROOM AND COAL HANDLING EQUIPMENT

Ash from the stokers is discharged to an industrial car running in a space below the boilers. This car is wheeled to the end of the boiler house where it is dumped into a hopper feeding a second Link-Belt elevator, set on an incline, Figs. 1 and 3; this deposits the ash in a 40-t. overhead cast-iron storage bunker, whence it is spouted to trucks for disposal.

Water for the power house and for building service is taken at 25-lb. pressure from the city mains and pumped to a 110,000-gal. Chicago Bridge & Iron Co. overhead supply tank. The pumps for this service and

for general service about the buildings are installed in a pump room between boiler and engine rooms, Figs. 1 and 2. Service pumps consist of two Yeomans single-stage centrifugals of 300-g.p.m. capacity each, driven by G. E. 220-v. induction motors. All returns from heating system and some from the laundry are brought back to the plant to be sent to the feedwater heater. In each building is installed a Nash vacuum pump for handling these returns and a similar pump is installed in the boiler house pump room.

Boiler feedwater, measured with a Yarway-Lea recording feedwater meter, is heated in a Webster open feedwater heater, of 50,000 lb. per hr. capacity, located in a space immediately over the pump room, with a Boylston atmospheric relief valve installed as shown. From this heater, water is pumped to the boilers by two Dean simplex, steam-driven, reciprocating feed pumps, each 10 by 6 by 12 in. in size. These are controlled by S-C pump governors and lubricated by Hills-McCanna force feed lubricators.

Laundry water is heated in a Patterson-Kelly heater of 4000 gal. per hr. capacity, using exhaust steam. A Fulton Sylphon temperature regulator controls the steam supply to this heater to give constant water temperature.

Steam Supply for Various Buildings

All exhaust steam from the main engines of this plant goes to an exhaust header running through the pump room, as shown in Fig. 1. To this are also connected the exhausts from stoker, engine and boiler feed pumps. From this line a branch is taken off for the feedwater heater, while the steam not used here goes on through the exhaust header to the underground tunnel lines leading to the heating system of the buildings. A Boylston pressure regulator maintains a pressure of 6 lb. on this exhaust header. From the main steam header behind the boilers, steam is taken off through a reducing valve, reducing from 150 lb. to 45 lb. for use in the kitchens. From this line a further reduction is made from 45 lb. to 6 lb. to supply live steam to the heating mains to make up any deficiency of exhaust. For use in the laundry, steam pressure is reduced from 150 to 80 lb. All reducing valves are Boylston.

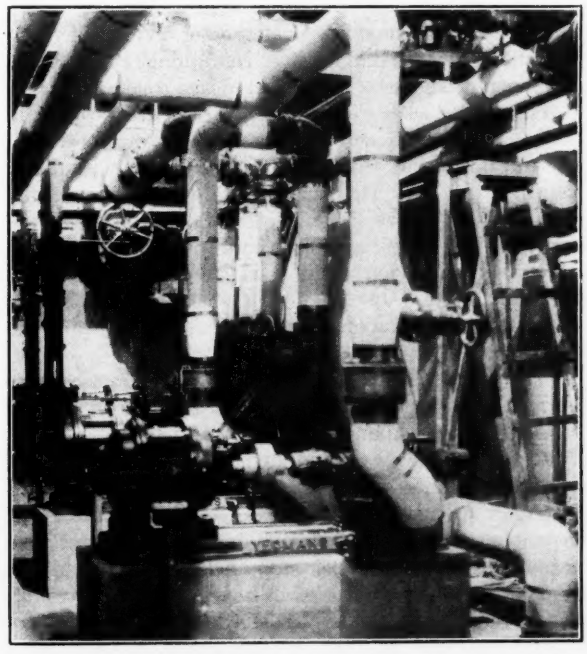


FIG. 2. PIPING IN PUMP ROOM IS PAINTED CREAM COLOR AND MATERIAL CARRIED BY PIPE IS STENCILED ON COVERING

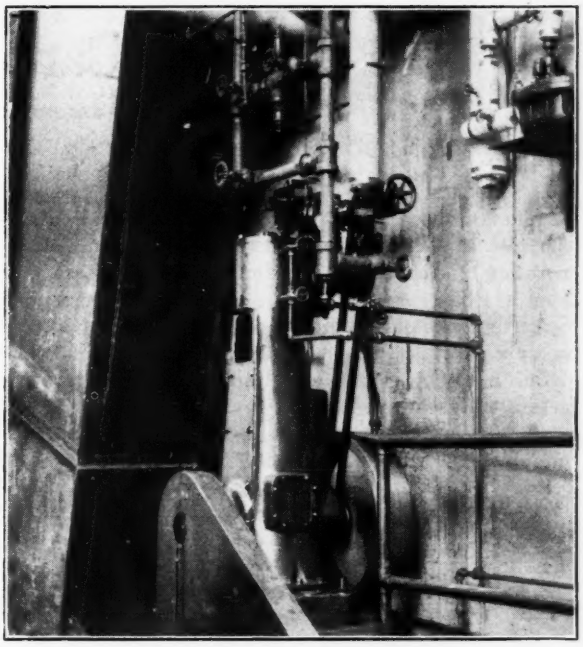


FIG. 3. STEAM ENGINE CONTROLLED BY PRESSURE REGULATORS, DRIVES THREE STOKERS AND FORCED DRAFT FAN. ASH HANDLING CONVEYOR IN BACKGROUND

This new power plant for Marygrove College was designed by D. A. Bohlen & Son of Indianapolis, consulting engineers. It was erected by W. E. Wood Co., general contractor for the college buildings, with Freyn Bros. as contractor for plumbing, power plant piping, heating and ventilating equipment. A. H. Sielken was resident engineer at the college for D. A. Bohlen & Son. The plant is operated under the direction of Chief Engineer Thomas Harrison. We are indebted to these men for data and for the most cordial co-operation when visiting the plant.

According to estimates made by the United States Department of the Interior through the Geological Survey, the developed water power was about 33,000,000 hp. at the end of 1926, an increase of 43 per cent in 6 yr. About three-quarters of the increase in the last three years has been in English speaking sections of North America. The total installed capacity for the United States at the end of 1926 was 11,700,000 hp. for plants of 100 hp. or more as against 13,100,000 hp. in Europe, presumably for plants of all sizes.

Although the potential power in the United States amounts to 35,000,000, the inference should not be drawn that 33 per cent of the water power resources of the country is developed. Probably with complete development the installed capacity would amount to 80,000,000 hp. or more; thus only about 15 per cent of the total resources has yet been developed.

Testing and Care of Venturi Meters

PART I. INSTRUCTIONS AND SYSTEMATIC PROCEDURE FOR CHECKING METERS AND KEEPING THEM IN CONDITION TO GIVE ACCURATE READINGS. BY FRED EMMARR

TESTING AND CARE of the instruments in power plants is usually left up to one or more individuals who are responsible for their continuous and correct operation. Often the responsibility ends there, so that after a while, particularly with change in personnel, laxity and misunderstanding creep in. Unless all details are carefully watched, there is always a possibility of failure to take cognizance of all corrections, operating factors, wear and the like.

At one large plant, including several boiler houses, pumping stations, power plants, compressor, and other

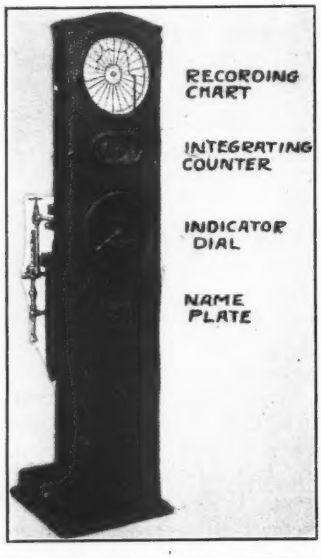


FIG. 1. TYPE M DOUBLE FLOAT VENTURI METER

auxiliary departments, a great number of instruments was maintained. This plant had about 30 Venturi meters in operation, besides other instruments.

To maintain standards and keep the changing personnel fully posted, a set of instructions was prepared giving a detailed routine of procedure in repairing and testing instruments. The object of these instruction sheets was to get the men to follow a routine of operation on a meter that would enable them to cover the entire instrument if desired, or to locate quickly any localized condition that needed attention.

At the same time, methods of correction and calibration were incorporated and a regular form designed to carry full records of the periodic check of the instruments.

This material is not obtainable from instruction books on Venturi meters, but was derived from actual experience with the instruments. It is made as complete as possible, with attention paid to every detail, in order to be a book of instructions to the caliber of young men usually selected as instrument men. This minimizes the personal instruction necessary and may save a lot of expensive experimental work on the part of the new man. For these reasons, much material which may seem detailed and trivial has been included.

The reader should distinctly understand that it is not the writer's intention to imply that all the adjustments mentioned here will necessarily have to be made at any one time on a given meter. Neither is it implied that all the possible troubles mentioned will occur in all Venturi meters or that many of them will occur in any one meter at a given time or with great frequency. It is apparent, however, that in inspecting the meter, if the maintenance man follows a systematic code of procedure, he will know exactly which parts of the meter are in good condition and adjustment and will be able to isolate any part that is out of adjustment and correct it very quickly. The following directions are intended, therefore, to cover all possible contingencies. Many of these, such as damage caused by freezing or dirt in the water, arise from

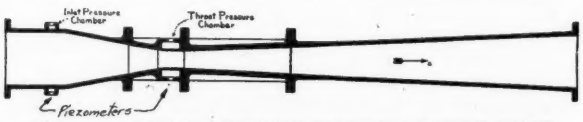


FIG. 2. SECTION THROUGH VENTURI METER TUBE

conditions external to the meter itself and can be obviated by proper care and supervision on the part of the operator.

THE DOUBLE FLOAT WATER METER, TYPE "M"

This type of meter, as illustrated in Fig. 1, differs materially from the single float type of water meter. It consists of two mercury wells, containing about 80 lb. of mercury, and two individual floats, racks and rack gears, one for each well. The two rack gears rotate in the same direction, actuated by the opposite motion of the two floats, but they turn upon a common shaft, as shown in Fig. 4. This shaft operates the cam A, and allied parts, such as the indicator dial hand, the aluminum yoke C, the integrating counter, the capillary pen which marks the chart, and so on, all of which are illustrated in Fig. 3. Operation of this meter is very simple and can be seen at a glance from the diagram; care and adjustment of it are equally simple.

The following directions may be helpful in ascertaining causes of meter trouble. They form a progressive method of checking and adjusting the meter:

1. If the meter is suspected of being out of order, consider mentally what may be wrong; whether it is high, low or merely sluggish; whether it be the clock, the integrator, or the valves or lines. If only one item is faulty, such as the clock stopping, it would be useless to open the meter. Endeavor to diagnose the trouble by a process of elimination, thus avoiding unnecessary work.

2. Examine the exterior of the meter for its general condition, such as splashing of liquids over and into the

meter, or accumulation of dirt and corrosion, appearance of vibration or distortion, incorrectly opened or closed valves, leaks, or broken lines. After a cold snap, examine meter for frozen and burst parts.

a. If the meter body has frozen and cracked without being distorted or bulged out of shape, it may be brazed or welded and replaced in service, but if the opening is large and the body deformed, it would be best to buy new parts or ship the meter back to the factory for repair.

3. Close the meter valves and open the blowdown valves, or break the line between the meter and the tube and allow the meter lines to flush out in a good stream, with the valves wide open until the lines become hot (if using meter for feedwater measurement) or the stream indicates that the lines have been cleared of all sediment. This cleans out the small piezometer holes in the meter tube.

a. This is important, as these piezometer rings may collect sediment and tend to become clogged and

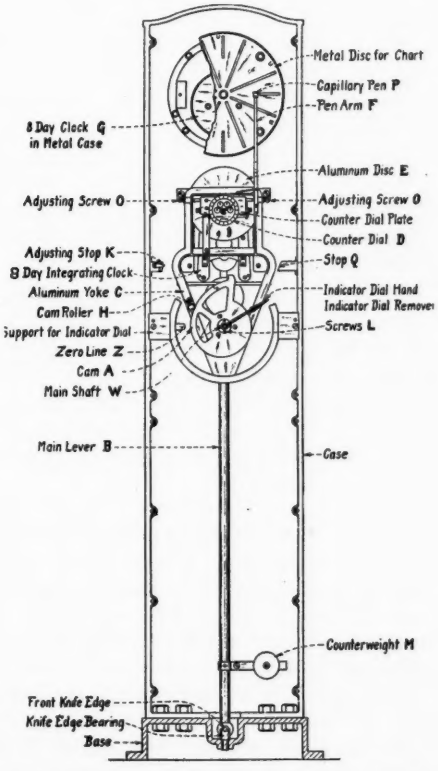


FIG. 3. DETAILS OF VENTURI METER ASSEMBLY

make the meter sluggish. If no arrangements have been made for blowdown of the meter, a drain should be placed on each meter line below the inlet valves C and D (Fig. 7), and the meters should be blown down regularly at least once a week.

4. With the meter and blowdown valves closed, open the bypass valve O, Fig. 7, which equalizes the pressure on both sides of the meter and allows the pen and dial hand to come to zero. If it moves very slowly or fails to reach zero, the meter probably is dirty or set incorrectly. This can probably be verified by the chart record, which may show too little fluctuation for the expected flow. If the pen moves rapidly and apparently freely, but fails to reach zero, the cam adjustment may be incorrect.

5. At this point, it may be well to check the assembly of the meter. The name plate on the front of the meter gives the tube number and the register serial number. This tube number should coincide with the number on the tube, and numbers stamped on the cam

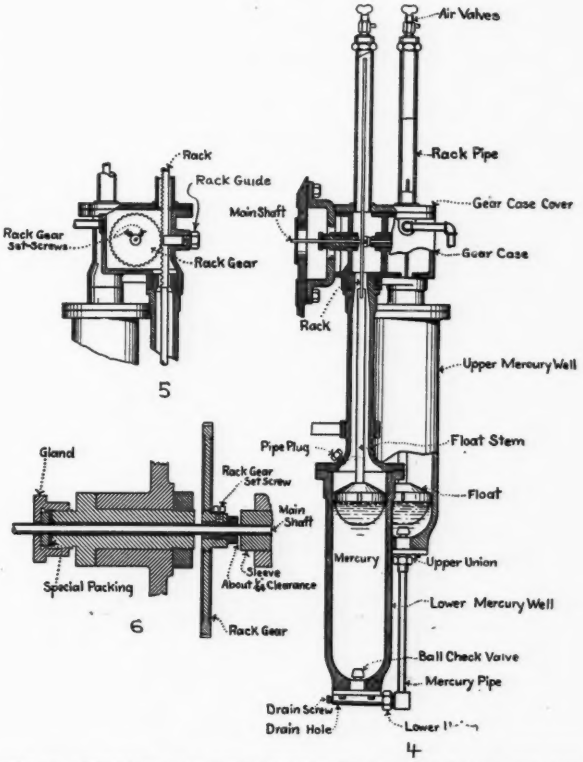


FIG. 4. DETAILS OF MERCURY WELLS AND MAIN SHAFT DRIVE. FIG. 5. RACK AND RACK GEAR DETAILS. FIG. 6. MAIN SHAFT PACKING GLAND

and the indicating dial should be the same as the register number. The integrator can be checked by means of its daily readings, comparing them with the chart total for the day. If the records of the original arrangement are lacking, these can be obtained from the manufacturer, who will gladly furnish such information. Of course, the chart size and number should agree with the size of the tube and the size indicated on the meter plate.

6. Open the upper front case of the meter and examine the interior parts for any unusual conditions. The pen should be cleaned of gummed ink, and pen arm should be held against the pin by means of the spring. With the yoke pressed against the adjusting stop K (Fig. 3), the pen point should rest on the zero line of the chart. If not, this should be set by means of the adjusting screw O.

7. Remove the indicating hand and dial covering the cam, and loosen the four set screws that hold the cam in place, screws L, in Fig. 3. The yoke should now move freely from right to left without much friction. Friction may be due to the adjustment of the integrator roller against the aluminum or rubber covered disk E, or rubbing of the aluminum yoke against the cam, due

to improper location of the cam or to a dirty knife edge at the base of the yoke.

a. The lower front case should be removed and the knife edges cleaned out. At the same time the counterweight M should be adjusted so that the yoke will follow the cam on the main shaft without excessive pressure on the cam.

b. The integrator tension against the disk is adjusted on some meters by a counterweight; the illustrated weight is adjusted by means of set screw on the downward extension arm. There should be practically no horizontal friction between the roller and the disk.

8. To reset the cam for zero, lift the adjusting stop K, hold the yoke to the extreme left and turn the cam to the left until the two marks, one on the cam and one

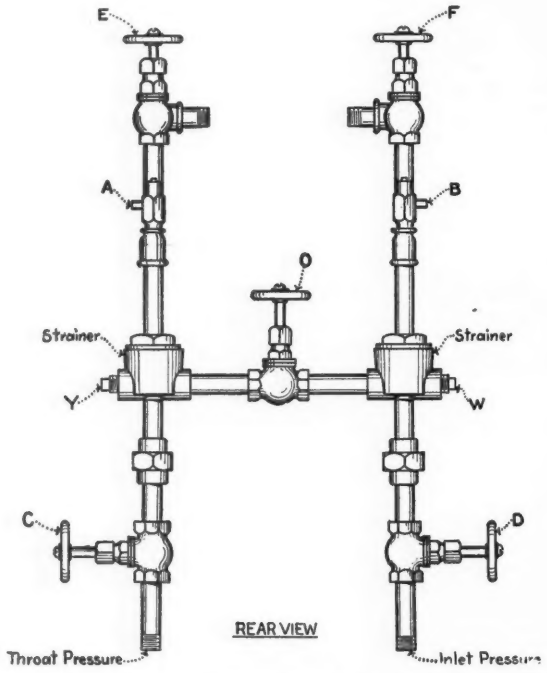


FIG. 7. PIPING CONNECTIONS, LOOKING AT BACK OF VENTURI METER

at the zero line Z, coincide exactly. Tighten the four screws L, holding the cam in position. Upon resetting the adjusting stop K, the pen should read exactly zero on the chart. This is the correct zero point for the meter.

9. It might be well at this point to try the meter out by opening the meter valves C and D, Fig. 7, and closing the bypass valve O. In a few minutes, again open the bypass valve and close the meter valve D. The pen should have gone out freely and returned exactly to zero. If not, the meter is sticking and must be cleaned.

10. The usual place of sticking is in the main shaft packing gland, illustrated in Fig. 6. The cam should be removed from the chart and a new piece of special packing put in. If the meter had not been cleaned for several months, it might be well to do so.

11. Remove the gear case cover shown on Fig. 4, exposing the racks and rack gears. Loosen the set screws on the rack gears. Depress the short low-pressure rack. If it cannot be pushed down at all, there is a shortage of mercury in the well, and more must be added through the pipe plug, until this rack can be depressed at least ¼ in. It should rise quickly upon release. Lift the long high-pressure rack. If it cannot be lifted, the wells contain too much mercury and the float is up against the top of the high-pressure well. Drain some mercury out of the bottom drain hole, taking care that the low-pressure float can yet be depressed and is free from the bottom of its well.

12. The main shaft should now be removed through the front, lifting out the rack gears as they are freed. The rack gears and the racks should be wiped off and cleaned, and the shaft should be polished with very fine or used sandpaper. If the meter interior appears very oily and dirty, it might be well to drain out all the mercury into strong iron mercury bottles by means of a small dipper. Then turn the full stream of hot water (alkaline feedwater preferred) into both sides of the gear case to flush out both wells. A hose with a high velocity nozzle should be used for this flushing.

13. If the ball check valves are gummed up and stuck, they may be removed and cleaned. The mercury should also be cleaned before pouring back into the meter, especially if oily and emulsified. A little gasoline breaks up this emulsion.

14. Upon closing the bottoms of the wells, the mercury can be again poured into the wells until the floats are at their proper heights. Use a funnel supplied for the purpose screwed into the pipe plug tap at the top of the high pressure well.

15. If the rack does not mesh properly with the rack gear, adjust the rack guides shown on Fig. 5. At this time it would be well to clean or replace the strainers on the inlet lines, shown on Fig. 7.

16. Reassemble meter complete and fill the meter body with water from the line, opening the air valves at the top of the rack pipes and meter inlet lines, until all entrained air is removed.

17. Reset the cam for zero as shown in Item 8 of these directions. Replace the indicator dial and set the indicator dial hand at zero. Put the meter on the line by opening the meter inlet valves and closing the bypass valve. All set screws should be made tight. A little fine oil should be placed upon all rubbing parts in the front section of the meter.

18. The meter is now clean and adjusted and should give correct operation.

19. The integrator or counter should be set for zero, by pressing the yoke against the stop K and loosening the set screw on the clock driving gear and rotating the disk rapidly in either direction. If the large counter hand rotates, the integrator must be moved in either direction by loosening the screws O and setting. If not enough adjustment can be made by means of screws O, the driving roller shown on Fig. 6 can be moved as required. The pivots at O must not be too tight nor too loose.

20. A quick check on the operation of the meter is to open the air cock on the top of the low-pressure rack pipe. This should cause the reading of the meter to rise rapidly, and drop quickly back to its original position upon closing this air cock.

(To be concluded)

Coal Heat Value from Ash

B.T.U. FOR DRY COAL DETERMINED GRAPHICALLY FROM ASH CONTENT. BY ARTHUR W. COLE*

EACH YEAR operation of a modern power plant or central station is becoming more of an exact science, so that to operate such a plant is the problem of the trained engineer.

As the purchase of fuel and the disposal of refuse constitute the greatest single item of expense for any plant, the operating engineer must strive constantly to reduce these items of expense. This is best accomplished by making every effort to reduce heat and fuel losses and to maintain the fuel quality. The fuel purchaser of today realizes that his only interest in the fuel lies in the heat he is able to realize from the fuel. The ash, clinker and refuse and expense of disposal only add to the cost of the heat purchased in a ton of coal.

Many factors combine to influence the heating value of a ton of coal. In fact, everything having a tendency to change the density or composition of coal will have an effect on the heat delivered by a pound of coal when burned in a boiler furnace. Of these heat diluting factors, moisture and ash are of greatest importance.

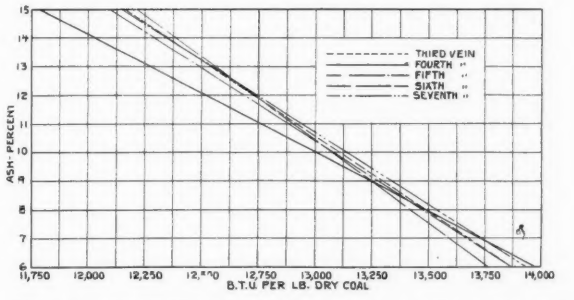


FIG. 1. FOR INDIANA SEAMS 3, 4, 5, 6 AND 7 HEAT VALUES AND ASH CONTENT ARE SIMILAR

Moisture, being added to the coal in such a large variety of ways, is always variable in amount. As moisture can be easily determined and thus eliminated from the problem of heat value determination of the coal, by moderate heating for an hour at 105 deg. C. (221 deg. F.), it can readily be eliminated from the problem. Ash, on the other hand, can be determined by heating a sample of the fuel in a covered vessel at 700 deg. C. (1292 deg. F.), until all the combustible has disappeared.

Although other characteristics such as volatile, fixed carbon and sulphur may have an effect upon the heating value of a given coal, these characteristics are practically constant for a given coal bed or seam. Coal, having been formed from vegetable matter which has undergone a natural process of distillation, it would seem only reasonable to find the same materials making up the combustible elements of a coal from a given field. Coals from any bed or section should, therefore, vary only in the amount of ash or earthy material mechanically mixed with the vegetable matter. Mineral matter or ash would naturally vary in proportion to the thickness of the vegetable deposit and the amount and violence of the folding of the earth during the process of coal formation.

Coal fields of Indiana are extensive. But the characteristics of Indiana coals are much less widely known than they should be, considering that Indiana is the seventh state with respect to coal production. Most of the Indiana coals come from seams 3, 4, 5 and 6. Examination of Indiana coals shows that, aside from moisture and ash, they are comparatively uniform in character.

Upon the supposition that, in dry coal of a given seam, ash would be the controlling factor of the heating

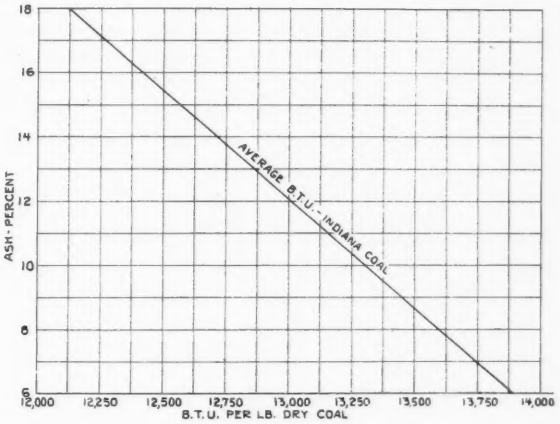


FIG. 2. AVERAGE VALUES FOR RELATION OF HEAT TO ASH CONTENT WILL BE AS ACCURATE AS ORDINARY EXPERIMENTAL DATA. CURVES FOR INDIANA COALS

value per pound, the accompanying curves have been drawn. The analyses from which these curves were constructed were made by United States Bureau of Mines, The Commercial Testing and Engineering Laboratories of Chicago and the research laboratory of Purdue University.

Heat value in B.t.u. determined by the bomb calorimeter may easily vary 2 per cent, so that curves plotted from these values cannot be expected to be more accurate. Since the heating value of coal is determined from small samples, it must be admitted that the problem of obtaining an accurate and average sample is extremely difficult, therefore the samples themselves may easily vary 2 per cent or more in their individual characteristics.

By using a large number of analyses of Indiana coal made by several different laboratories, B.t.u. ash curves have been drawn for seams 3, 4, 5, 6 and 7. After completing these curves, they were found to be very similar and a single curve, Fig. 2, was made by averaging the values of the individual vein curves. If the theory is correct that ash is the controlling factor in the heating value of dry coal, in any coal basin, this average curve

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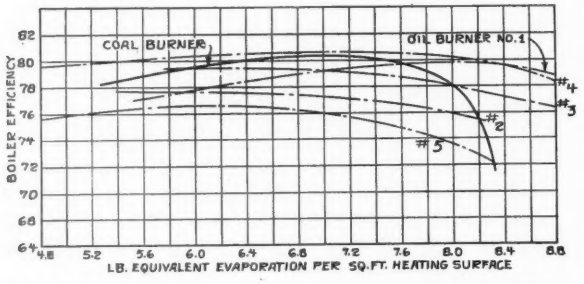
should yield values closely approximating the bomb calorimeter heat value of Indiana coal.

The average curve was tried by using the dry ash from analyses and reading the heat value from the curve. This value was then compared with the calorimeter value and in no case did the curve values differ over two per cent from bomb determinations. Since such a difference is within the accuracy of sampling, it would appear that such curves, established for the various coal deposits, would be of value to both plant operators and engineers in determining approximately the heating value of any coal, as well as checking the heat value of the power plant coal supply.

Turbulent Burner Tests in Small Furnaces

Heat Releases of 141,600 B.t.u. per Cu. Ft. of Primary Combustion Space Obtained in Scotch Marine Boilers

RECENT developments in pulverized coal burning, particularly in reference to the work being done by the Fuel Conservation Committee of the Merchant Fleet Corp., U. S. Shipping Board, was described on page



EFFICIENCY CURVES OF PULVERIZED COAL BURNERS AND SEVERAL DIFFERENT TYPES OF OIL BURNERS

1032 of the October 1, 1927 issue of Power Plant Engineering. Test results were recently made public in a paper entitled "Test of Pulverized Coal as Applied to Scotch Marine Boilers," presented by C. E. Jefferson and J. S. Evans before the Society of Naval Architects and Marine Engineers in New York, November 10 and 11.

Tests were carried on in the S. S. West Eagle, which is equipped with a single ended Scotch marine boiler with three furnaces and separate combustion chambers. The burners used were Peabody combined fuel oil and pulverized coal burners operated in connection with a Kennedy air-swept tube mill.

A summary of the data is given in the table. Attention is called to the heat release values obtained, as listed under "Hourly rate fuel fired per cubic foot combustion space, B.t.u. content." The values obtained on this test are not only unique in marine practice, but also in stationary practice, and it will be noticed that a rate of 59,984 B.t.u. was maintained during the last 48-hr. period.

In contrast to this value it is to be noted that the average value obtained in stationary practice is somewhat less than 20,000 B.t.u., the highest value reported in the latest report of the Prime Movers Committee on pulverized fuel being 41,600 B.t.u., which figure, moreover, is based on primary combustion space only, while the 59,984 B.t.u. shown in the table takes into account the entire combustion space. If the primary combustion spaces or furnaces alone be taken, as they well might be, insomuch as the flame does not extend beyond the horse collar of the furnaces, this value would be over 141,600 B.t.u., or approximately 350 per cent greater than the maximum heat release per cu. ft. of furnace volume recorded for present stationary practice.

Pulverized Coal Averaged About 70 Per Cent Through 300 Mesh

This heat release has been accomplished by flame turbulence, and a high percentage of superfines in the pulverized coal.

DATA FROM TESTS ON A SCOTCH MARINE BOILER

Test division number	I	II	III	IV	V
Hourly rate - fuel fired per cu.ft. combustion space, lb.	2.57	2.94	3.40	3.83	4.20
Hourly rate - fuel fired per cu.ft. combustion space, B.t.u. content	37,162	42,057	48,878	55,841	59,984
Moisture, per cent	2.1	2.9	2.6	2.4	2.8
Heat value, B.t.u.	14,460	14,305	14,376	14,580	14,282
Pulverized Coal Screenings					
Through 50 mesh, per cent	98.6	99.7	99.2	99.3	99.3
Through 70 mesh, per cent	95.9	98.4	96.6	96.8	97.0
Through 100 mesh, per cent	91.2	94.6	92.0	92.9	93.1
Through 140 mesh, per cent	86.4	89.9	87.1	88.2	88.1
Through 200 mesh, per cent	77.4	80.9	78.1	79.8	79.2
Through 300 mesh, per cent	68.0	70.4	68.5	69.3	69.9
Air Data					
Total weight of air per lb.of fuel fired, lb.	12.44	11.90	11.73	11.79	12.15
Excess air, per cent	14.36	10.28	8.99	7.87	15.62
CO_2 content average	16.18	16.71	17.01	17.10	16.26
Power Required for Pulverized Coal Kw. per Hour					
Primary air fan	2.11	2.24	2.37	2.26	2.90
Coal feed	.15	.19	.13	.12	.07
Distributor	.31	.30	.33	.33	.21
Pulverizer	18.00	18.00	18.00	18.00	18.00
Total	20.57	20.72	20.83	20.71	21.18
Steam and Water Data					
Boiler pressure absolute, lb. per sq. in.	190.3	190.0	190.8	191.5	192.1
Temperature water to boiler, Deg.F.	208	209	211	207	210
Moisture in steam, per cent	.20	.19	.19	.18	.16
Temperature of saturated steam, deg. F.	377.72	377.60	377.92	378.25	378.54
Factor of evaporation	1.052	1.052	1.050	1.054	1.050
Economic Results					
Actual evaporation per lb.fuel fired, lb.	10.61	10.81	10.54	10.46	9.86
Equivalent evaporation per lb.fuel fired, lb.	11.16	11.36	11.07	11.02	10.34
Equivalent evaporation per lb.dry coal fired	11.41	11.61	11.37	11.30	10.65

Several oil burners have been tested on this same boiler, the efficiency curve of these burners being determined for 2-hr. peak period during the day's run. It is felt, therefore, in order to make a comparison between the results obtained with pulverized coal and the results obtained with fuel oil, that the peak period for a 240-hr. test be used for determining the pulverized coal characteristic efficiency curve. In this case, however, instead of 2-hr. periods, 8-hr. periods have been taken.

As there is a difference in the heat content of oil and coal, the comparison between the two types must be based on something other than weight. The factors selected in drawing up Fig. 1, on which this comparison is shown, are boiler efficiency, plotted against equivalent evaporation per square foot of heating surface. It is to be noted that of the five commercial burners plotted

on the chart, only one shows an efficiency rate in excess of the pulverized coal for evaporation rates less than 7.5 lb. per sq. ft. of heating surface. The oil burner No. 4, which tops the pulverized coal curve, has positive control of air supply to each individual burner. This in a manner effects the condition which would be obtained with perfect distribution in the case of the pulverized fuel installation.

It is probable that the drop in the pulverized fuel curve, as indicated by the dotted section for evaporation rates in excess of 8 lb. per sq. ft. of heating surface is somewhat greater than it should be. These points were determined from values obtained after 200 hr. steaming when the boiler had become scaled from 3,000,000 lb. or more of water which had been evaporated and discharged to the atmosphere. This, of course, would affect the efficiency figures.

Moreover, during the particular run for which these figures were obtained, trouble was experienced with the primary fan bearings which made it necessary to run with 2.2 in. discharge pressure instead of the contemplated 2.7 in. pressure, a condition that reduced the turbulence of the flame and affected efficiency of combustion. With the latter mentioned defect corrected and with clean boilers, the performances obtained would probably have plotted between curve of oil burner No. 3 and oil burner No. 4, as in fact it does at the 8.08 rate.

Use Care in Repairing Foundations

Repairs to Foundations Should Be Made Only After the Old Surfaces Have Been Thoroughly Cleaned with Chemicals. By James F. Hobart

MUCH OF the concrete work done by power plant engineers consists of the repair of existing foundations or changes to accommodate new machines. This requires the greatest skill and only too often proves a miserable failure because of the lack of that skill and experience in making the new concrete adhere to the old.

To repair a damaged concrete foundation, every bit of loose concrete should first be removed and particles of dust cleared away either by compressed air, or by more laborious work with a stiff brush. It may even be necessary to loosen some of the wedged-in broken pieces with a sharp packing hook or awl—the method is unimportant, but every broken piece must be removed, no matter how tedious and troublesome the work may prove to be.

Having made sure that all loose bits of concrete have been removed, look closely for grease or dirt, and if the slightest trace of either be found, it must be removed before proceeding further. Heavy coatings of dried-on grease should first be thoroughly scraped, then washed with chemicals. Procure a pound or so of potash and dissolve it preferably in hot water, for although cold water will do the work, it will require a much longer time. This potash solution should be made strong enough to float an egg one-third of its volume above the surface of the solution. If potash cannot be obtained, procure a can of concentrated lye and make a solution of the same strength. Then, with the solution and a fiber-filled scrub-brush, scrape and dig the dried-on grease until every particle has been removed. The grease and dirt must all come off or there can be no union with the old and new concrete. Be careful not to let the potash or lye solution splash around, for this powerful grease remover will burn both flesh and clothing.

Thorough Washing with Water Is Necessary

After the grease and dirt have been loosened and brushed away, wash the old concrete with plenty of water until every trace of the alkaline solution is gone, as the next step is to wash thoroughly with acid and, unless the alkali has been thoroughly removed, it will neutralize all acid with which it comes in contact, wasting the acid and interfering with its work. A stream of water from a hose is the most convenient and satisfactory method of washing thoroughly.

Acid solution is made by diluting hydrochloric (muriatic) acid with clean water until the solution barely boils when applied to the cleaned and washed concrete. This solution must be mixed in a glass or earthenware dish, as it will attack and eat metal. Then with the dilute acid and another fiber brush, every portion of the old concrete which is to come in contact with the new concrete should be thoroughly scrubbed. The acid will dissolve away the outer surface of the old concrete particles making them clean and bright and put them in such condition that the new concrete can and will bond completely with the old, something quite impossible when the old concrete is dirty, greasy, or both.

Take care, no matter how thoroughly the old concrete is cleaned, unless the acid solution is entirely washed away, it will keep on dissolving the particles of concrete, and literally cut the new and old concrete, leaving a film of dissolved material between them. It is, therefore, necessary to wash thoroughly with lots of water and then, while the old concrete is still wet, begin to build up the broken parts of the foundation, using freshly mixed concrete for replacing the broken parts or building the new.

It is best to fit the concrete form before cleaning the old concrete as then it will only be necessary to put the form in place after cleaning has been accomplished. This avoids any possibility of spoiling the clean portion when the form is being erected.

Concrete Should Be Mixed in Small Batches

Should any portion of the clean concrete become dry before the new concrete is placed, it must be again wet thoroughly before the new material is placed. Furthermore, the soft concrete should be puddled with a clean steel rod so as to displace any air bells which might adhere, and to remove any large bits of aggregate and permit the active fine cement to reach and unite with the old concrete.

Should any of the freshly mixed concrete chance to remain unused for more than a few minutes or until initial set has taken place, do not try to mix that concrete soft again. Some of its setting and hardening qualities have been consumed in the initial set, and concrete made after this set has taken place and dis-

turbed can never be as good as concrete placed before the initial set took place. While such concrete might be strong enough to be placed in a big foundation, take no chances with it upon a repair job.

Do not try to repair cracked concrete by merely filling in the cracks, for although the crack may be closed in that manner, the filling will not adhere to the old concrete on either side. If, however, appearance and not strength is the reason for treating the crack, clean the entire outside of the foundation with chemicals as previously described, fill the cracks and paint the foundation with a neat cement mixed to a cream with clean water and applied with an ordinary paint brush. In this way any job of concrete, either new or old, can be made to look as though the work has been done, from start to finish, by professional concrete makers.

To make an existing foundation larger, proceed in the same manner as for repair work. Be sure that the old concrete is cleaned and there will be no trouble in making the new concrete adhere to it perfectly.

Brick foundations may readily be repaired or added to either with bricks and mortar or with concrete, by first cleaning the old surface thoroughly with alkali and acid and adding either bricks and mortar or concrete for repairs or additions. Mortar will adhere to chemically cleaned surfaces as readily as cement and concrete will.

Cement paint will work as well upon chemically cleaned brick work as on concrete. If the cement gray proves unpleasing, work some dry vermilion into the paint and pleasing results may be expected. Mixing the cement with strong copperas water will impart a greenish hue which, however, may not prove very permanent. Be careful in using concrete paint not to mix a larger batch than can be used in a few minutes, as initial set spoils it.

Plant Auxilliary Equipment Is Important

FANS AND PUMPS USUALLY CONSIDERED AUXILIARY EQUIPMENT, MUST BE GIVEN CAREFUL CONSIDERATION IF RELIABILITY AND ECONOMY ARE DESIRED

BECAUSE OF THE overshadowing importance of the larger items of power plant equipment, plant auxiliaries and the importance of their relation to the plant as a whole are often overlooked. Fans and pumps play a considerable part, not only in the reliability, but in the economy of the plant as well.

Fans used for mechanical draft may be of either the propeller or centrifugal type. Of the centrifugal type fans, the multi-blade is commonly used both for induced and forced draft, as large volumes of air and gas must be handled usually against relatively high pressures. The high speed disk fan is usually used on small boilers for boosting the rating at peak load. Both the disk and ordinary steel plate type fans are used for ventilation, depending largely upon the arrangement and the quantity of air handled. Pumps may be of either the centrifugal, power-driven positive displacement or direct steam acting types. Centrifugal pumps, like fans and blowers, may be driven by motor, turbine or engine, as desired.

Formerly steam-driven auxiliaries were used exclusively, but the introduction of the bleeder turbine changed conditions somewhat so that motor-driven fans and centrifugal pumps are now in general use. Steam-drive offers some advantages in regard to reliability and simplicity of speed control; however, electric control has been perfected to a point where it is reliable and effective so that even though somewhat more complicated it is often favored because of the economy when

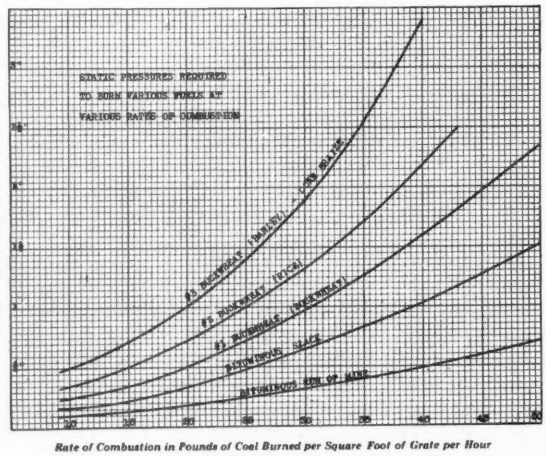


FIG. 1. ASH-PIT PRESSURES REQUIRED FOR HAND-FIRED BOILERS BURNING VARIOUS KINDS OF FUEL

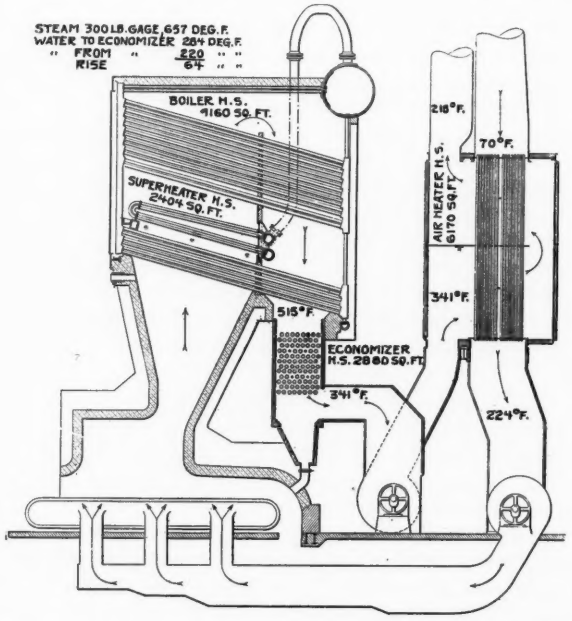


FIG. 2. LAYOUT OF A MODERN CENTRAL STATION SHOWING THE ARRANGEMENT OF THE FORCED AND INDUCED DRAFT FANS AND THE TEMPERATURE OF THE AIR HANDLED

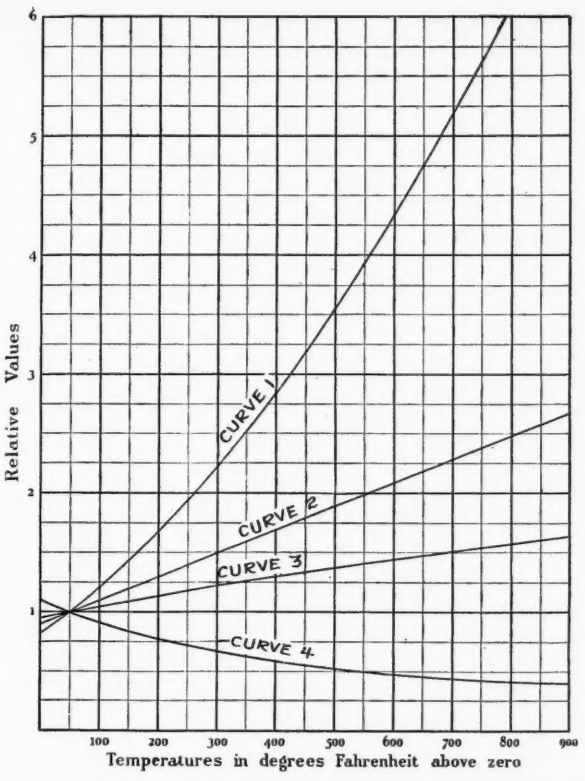


FIG. 3. RELATION OF VOLUME, WEIGHT AND PRESSURE OF AIR AND POWER TO THE FAN WITH AIR AT DIFFERENT TEMPERATURES

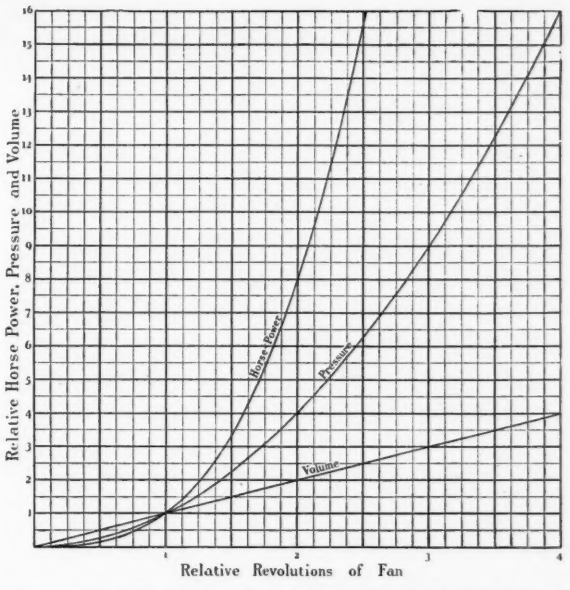


FIG. 4. THEORETICAL RELATIONS BETWEEN THE SPEED OF THE FAN, VOLUME DISCHARGED, PRESSURE CREATED AND HORSEPOWER REQUIRED

used with the extraction cycle or simplicity of installation, due to elimination of considerable steam piping.

Centrifugal boiler feed pumps are built for speeds of 3600 r.p.m. for motor drive and sometimes higher speeds for direct connection to steam turbines. Fan speeds do not range as high, although they are sometimes built for a speed of 1750 r.p.m. For motor drive, either direct or alternating current may be used for both pumps and fans. Variable speed drive is to be preferred for fans. Speed controls may be automatically or manually operated, in the latter case, the control should be located in the boiler room. When constant speed motors are used with fans, it is necessary to install regulating dampers for control of the air supply.

Conditions under which the various pieces of equipment operate vary considerably, not only with the function of each particular machine, but with the characteristics of the individual installation. Figure 1 shows the variation of ash-pit pressure for different fuels for hand firing. Naturally these are average values, as the exact pressure varies with the coal, thickness of the fuel bed, ash bed and type of grate.

Rising Pressure Characteristic Preferable

Forced draft fans should exhibit a constantly rising pressure characteristic from free delivery to no delivery. Moreover, this should be relatively steep in order to create a sensitive condition to changes in air resistance through the fuel bed, as at constant speed, a small variation in pressure, such as might occur in the burning fuel bed, should produce a minimum change of air quantity delivered by the fans. The constant rise of the pressure curve will insure satisfactory operation when several fans discharge into the same duct, as is frequently the case.

Forced draft pressures for the larger plants have gradually increased from 1½ or 2 in. water gage to 8 or 10 in. and even higher with the temperatures of preheated air up to around 600 deg. F. In stoker-fired plants, the practical temperature limit seems to be around 300 to 350 deg. due to mechanical difficulties with the stokers at higher temperatures and because the volume of necessary air at higher temperatures is so great that the draft required to force it through the fuel bed has a tendency to lift the finer coal off the grates.

Induced fan practice has been subject to the same changes and because they handle the hot exhaust gases, their service is particularly severe. Use of air preheaters has increased the induced draft requirements considerably. Speeds of both types have increased to a maximum of about 1750 r.p.m., not only because of the demand for smaller, cheaper units, but because of the requirements of alternating current motor drives with a more or less fixed speed.

In Fig. 2, a modern installation using air preheaters, economizers, forced and induced draft fans and stokers, is shown. The temperatures are indicated. In this case both fans handle hot air and gases, but in many plants the fans can be placed on the other side of the preheater where the temperatures are lower. Increase in the air temperature has a decided effect on the fan performance, as shown in Fig. 3, based on conditions at 50 deg. F.

Curve No. 1 shows the power necessary to operate the fan at increased pressures necessary to handle the same weight of air. If the fan is properly proportioned and designed for the higher temperatures, however, this power requirement is reduced to curve 2, which also gives an idea of the relative volume and speed required

to handle the same weight of air under the higher temperature. Curve 3 shows the speed increase necessary to maintain the same draft regardless of volume while curve 4 shows the weight of air for the same volume and power decrease if the speed and volume remain fixed.

Effect of speed increase of the same fan is shown graphically in Fig. 4. These curves are approximate and are based on the assumption that the volume varies directly as the speed, the pressures as the square and horsepower as the cube of the speed.

Blast areas for standard steel plate fans may be calculated roughly from the equation:

$$a = W\ D \div 3$$

where a = square inches of blast area.
W = width of blade to tips.
D = diameter of impeller in inches.

Theoretical horsepower and capacity per square inch of blast area for various pressures can be found in

TABLE I. APPROXIMATE POWER REQUIREMENTS FOR FANS UNDER DIFFERENT DRAFT CONDITIONS

Water gage, in.	Capacity cu. ft. per min. per sq. in. of blast area	Theoretical hp. to move given volume
0.2	12.2	.0004
0.4	17.2	.0011
0.6	21.15	.0020
0.8	25	.31
1	27.3	.43
1.5	33.8	.79
2	38.8	.0122
2.5	43.3	.0169
3	47.5	.0224
3.5	51.4	.0282
4	54.8	.0344
5	51.2	.0481
6	66.9	.0230

Table I. For any particular fan the table and equation used and published by the manufacturers for their particular fan should be used in preference to the above general figures.

Duct Velocity Should Depend on Static Pressure

If ducts are used the pressure loss through them must not be neglected in figuring the performance of a fan. Where possible rectangular ducts should have a ratio of side not greater than 1½ to 1. Ducts should be as short and straight as possible with easy elbows and of a sufficient cross section to permit low velocity. The maximum velocity in a duct under extreme peak conditions should not be greater than 10 per cent of the static pressure. Thus if the static pressure in a duct is 5.5 in. of water the velocity pressure should not be over 0.55 in. of water corresponding to a velocity of about 3000 ft. per min., a safe figure for the maximum air velocity is 2400 ft. per min.

When laying out the main air duct, the area should be determined by using a velocity based on a velocity pressure of from 5 to 10 per cent of the static pressure. Table II shows the relation between velocities and static pressures on this basis. The area of the branch air lines leading to the boiler should be such that the velocity will not be more than 2/3 that in the main duct.

Table II is based on the weight of air at 0.07488 lb. per cu. ft., which corresponds to a temperature of 68 deg. F., and a barometric pressure of 29.92 in. and 50 per cent relative humidity. For higher elevations or temperatures, the above velocities may be increased 1 per cent for each 500 ft. increase in elevation and 1 per cent for each 10 deg. F. increase in temperature.

TABLE II. VELOCITIES CONSIDERED GOOD PRACTICE FOR MAIN AIR DUCTS

Static pressure, in.	Velocity in main air duct 5 per cent	Velocity in main air duct 10 per cent
2	1300	1800
2½	1400	2000
3	1550	2200
3½	1700	2400
4	1800	2550
4½	1900	2700
5	2000	2850
5½	2100	3000
6	2200	3100
6½	2300	3250
7	2400	3350

Any change in the direction of the air flow should be accomplished by means of bends having a radius of throat not less than half the diameter of a round duct or ½ the width of a rectangular duct. With rectangular ducts the ratio of one side to the other should preferably not exceed 2 to 1. If this ratio must be exceeded, lower velocities should be used, the reduction being 5 per cent

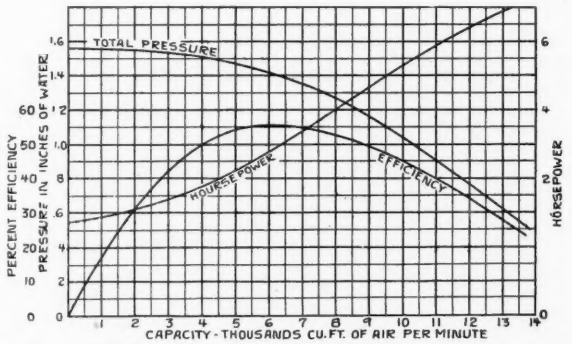


FIG. 5. TYPICAL POWER AND PRESSURE CHARACTERISTICS OF AN INDUCED DRAFT CINDER FAN

for a ratio of side 3 to 1, 10 per cent for a ratio of side 4 to 1, and 15 per cent for a ratio of side 5 to 1.

It is customary practice in selecting apparatus for mechanical draft purposes to allow for 100 per cent excess air for hand-fired boilers, 16.70 cu. ft. of air per min. at 70 deg. F. per boiler horsepower for forced draft fan, and 32.40 cu. ft. per min. at 550 deg. F. for an induced draft fan. An allowance of 50 per cent excess air is made when the boiler is equipped with a stoker, or 11.70 cu. ft. per min. at 70 deg. F. per boiler horsepower for forced, and 22.80 cu. ft. per min. at 550 deg. for an induced draft fan. This, of course, is dependent

upon the kind of stoker used, size of installation, rating carried and other individual characteristics.

Power plants located in congested districts have need of some means for preventing the discharge of cinders which may take place with certain fuels when operating at high rating. While this is not a common condition, the demand for separating devices has existed. Several different types, including electrostatic precipitation, cyclones and cinder eliminating fans have been developed. Characteristics of one cinder fan requiring about the same amount of room as a standard induced draft fan of the same capacity and which has shown excellent results in the removal of fine discharge of cinders is shown in Fig. 5. Characteristics differ little from those of any regular rising pressure characteristic fan or from those of centrifugal pumps. As with centrifugal pumps, these characteristics are determined by measuring the quantities for various orifice openings and plotting the curve for several test points.

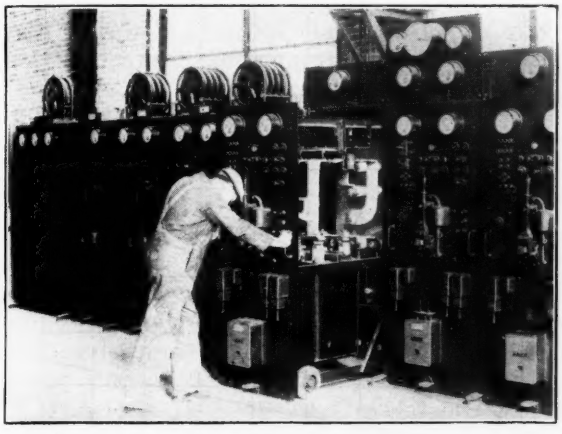


FIG. 6. A VIEW OF A WELL-ARRANGED COMPLETE SWITCHBOARD IN AN INDUSTRIAL PLANT

Ventilating Problems Are Becoming Important

Ventilating problems in power plants are numerous and of great variety. The ventilation is largely made necessary by the increasing cost of buildings and the value of the space occupied. It is only by mechanical ventilation that most of the power plants and transformer stations built in the last few years could operate. Factory room condenser wells and switch houses are often designed with a view for forced circulation of air for cooling, while generator cooling systems are occasionally installed with separate fan systems, although this is not common. Air temperatures are usually relatively low for these services, although the pressure required for an extensive plenum chamber system may be considerable.

Pumps also play an important and necessary part in the power plant. Performance of circulating, condensate, and condenser vacuum pumps were considered in the January 1, 1928, issue of Power Plant Engineering, to which the reader is referred. In addition to these, boiler feed pumps are a necessary adjunct to all plants, while general service pumps are often provided, in fact, must be provided where city water pressure is not available in the plant.

Boiler feed pump pressures ordinarily run from 10 to 50 lb. higher than the corresponding boiler pressures. So far the highest boiler pressures in use in this country have been around 1400 lb. It is now common practice to use boiler feedwater regulators. In addition it is advisable to maintain a constant pressure differential across the feedwater regulator when high pressure boilers are used.

If steam-driven pumps are provided, the pressure regulation is maintained by speed changes of the pump. This is sometimes done with motor-driven pumps, but the more common practice for centrifugal pumps is to have the pump characteristics such that the regulation can be maintained by throttling the discharge. In some cases an automatic bypass from the discharge to the suction side is provided and set to open when the discharge pressure becomes excessive.

Electric power input to motor-driven machines can be determined by means of a wattmeter or by the combined use of a voltmeter and ammeter for direct current, or voltmeter, ammeter and power factor meter for alternating current. Each important auxiliary or group of auxiliaries should be provided with a watthour meter, preferably mounted on the switchboard panel, as in Fig. 6. Watthour meters give the total integrated power consumption for the periods between readings, while the ammeter indicates the relative load at any time. For analyzing the performance of individual machines, recording ammeters and wattmeters can often be used to advantage.

Activities of the Electric Plant and Water Department of the City of Jacksonville, Fla., for the year 1928 include several important changes and additions. This department is under the control of Frank H. Owens, Commissioner of Public Utilities, and the general supervision of O. V. Tyler, Superintendent. In the Electric Division an extension of the main generating station of Tallyrand Avenue is under way. This includes the installation of three 1500-hp. boilers and one 25,000-kw. turbo-generator with the necessary auxiliary equipment.

There was also built, equipped and put into operation a number of new substations or substation additions, totaling some 7000 kv.a. and 22,214 new services added to the system. Another substation which will contain two 6000-kv.a. transformers, banks and the necessary equipment will be placed in operation shortly, and 10 distribution circuits will be handled from this one station. In the Water Department, a new 6,000,000-gal. reservoir was put in service, and two new 12-in. wells and a 7,000,000-g.p.d., motor-driven pumping unit were added to the supply system.

Latest research work undertaken by the Mechanical Engineering department at University of Michigan, Ann Arbor, Mich., is the study of bituminous coal in its relation to the manufacture of ordinary city gas. The study is to be made by E. S. Pettyjohn, under the direction of Prof. Alfred H. White, head of the Chemical Engineering department. The study will be carried on at the Marysville gas plant of the Detroit Edison Co. and the official report on Mr. Pettyjohn's findings will be presented at the convention of the Michigan Gas Association at Mackinac Island on July 5-7.

Diesel Engine Thermal Efficiency and M. E. P.

METHOD OF QUICKLY DETERMINING THE THERMAL EFFICIENCY OF A DIESEL ENGINE FROM ITS CARD, BASED UPON A NEWLY DERIVED FORMULA BY B. M. THORNTON

ACCOMPANYING chart was constructed with the following equation for the thermal efficiency of internal combustion engines working on the Diesel cycle, as a basis:

$$E = 1 - (1 \div r^{n-1})\ (R^{n-1} \div [n(R-1)]) \quad \ldots\ldots 1$$

where

E = thermal efficiency.
r = compression ratio.
R = cut off ratio.
n = exponent in adiabatic expansion and compression.

Derivation of this formula from first principles will

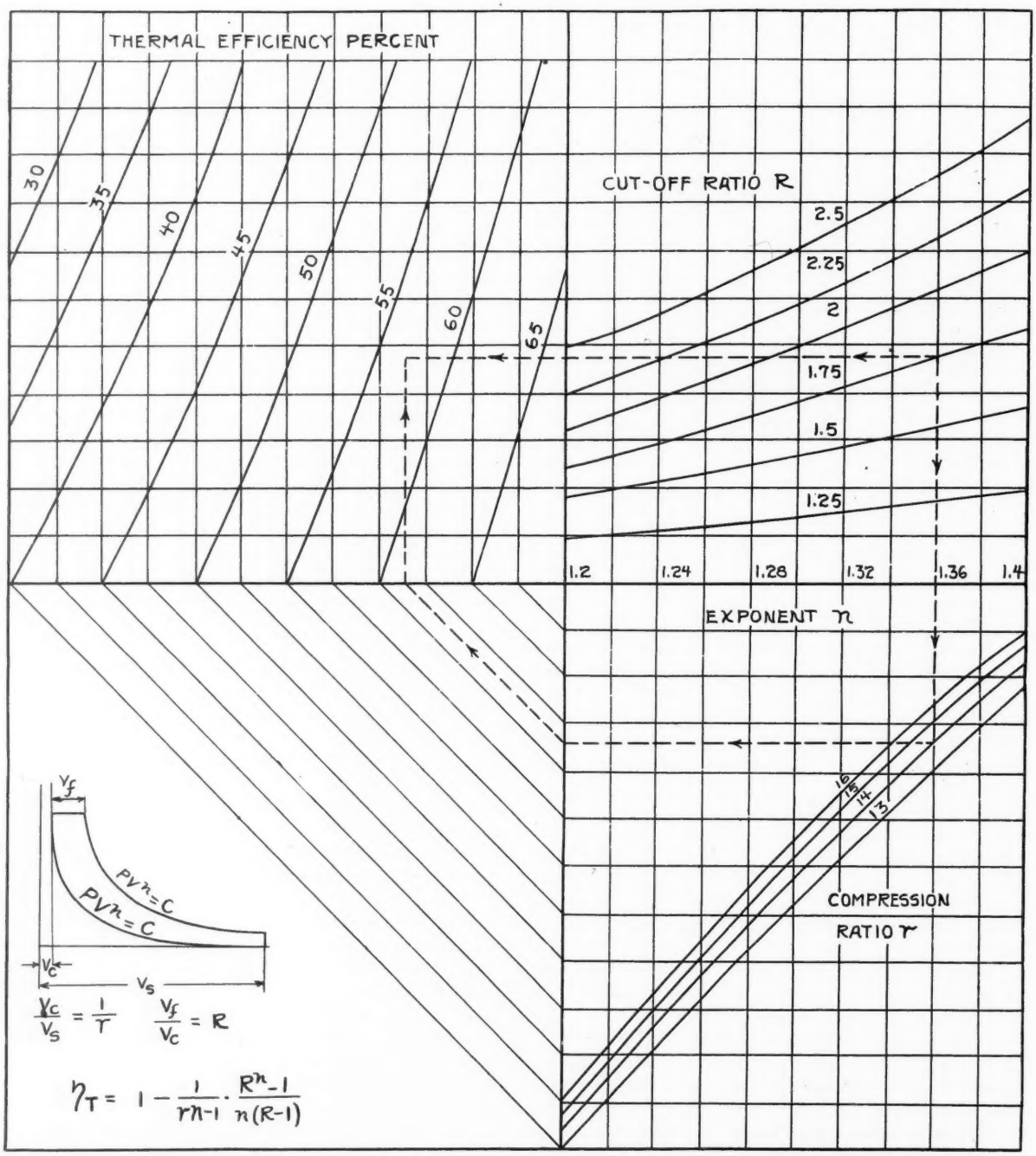


CHART FOR DETERMINING THE THEORETICAL THERMAL EFFICIENCY OF INTERNAL COMBUSTION ENGINES

be found in many text books and need not be given here. It should be noted that it is the mean value of the exponents of the adiabatics and in the actual engine that is to be used. This, owing to the variation of the specific heats, will not be 1.4, which is the value for air assuming no change of specific heats. A value which will give good accord with practice is 1.3. The method used, therefore, is that recommended in the report of the Institution of Civil Engineers (Great Britain); that is, to retain the air standard cycle and correct the exponent to allow for variation of specific heat.

The method of using the chart is shown by an example in which the quantities 1.36, 14 and 1.75 are used for n, r and R, respectively; the thermal efficiency works out at 57 per cent. Apart from the rapid solution of the equation, the chart has the advantage of showing clearly the effects of the thermal efficiency of variations in any of the three factors involved.

By consideration of the ideal indicator diagram as shown in the small sketch, the theoretical mean effective pressure may be derived in exactly the same manner as in the case of the steam engine. The mathematical steps would be too lengthy to include them in a short article but the formula attained is:

$$P_m = P_s[r \div (r - 1)] \; [(R - 1) \div (n - 1)] \; [nr^{n-1} - (R^n - 1) \div (R - 1)] \ldots\ldots 2$$

where

P_m = effective pressure in lb. per sq. in. abs.

p_s = charge pressure in lb. per sq. in. abs.

Facilities for searching through text books and papers on this subject are not available to the author but he has not seen this formula presented in this form elsewhere and although unwieldy, it is sometimes useful. As in the case of the steam engine, the actual mean effective pressure is estimated by the use of a "diagram factor" which will depend to some extent on the type of engine.

Another formula for the mean effective pressure of the Diesel cycle was given by W. J. Kearton in "The Motor Ship" for September, 1921.

$$P_m = K_v T_s \div V_s \; [r \div (r - 1)] \; (nRr^{n-1} - nr^{n-1} - R^n + 1) \ldots\ldots 3$$

where

P_m = mean effective pressure in lb. per sq. ft. abs.

K_v = specific heat of air at constant volume.

T_s = absolute suction temperature.

V_s = volume of cylinder and compression space, cu. ft.

It may be shown that Kearton's formula is identical with that of the author. This follows from the fundamental gas equation:

$$R = K_v (n - 1) \ldots\ldots 4$$

where

n = ratio of the specific heats at constant volume and constant pressure, i.e., exponent of the adiabatics.

R = the gas constant.

also

$$P = RT \div V \ldots\ldots 5$$

where

P = abs. pres. in lb. per sq. ft.

V = vol. of gas per lb.

T = abs. temp.

or, from 4:

$$P = K_v(n - 1)T \div V \ldots\ldots 6$$

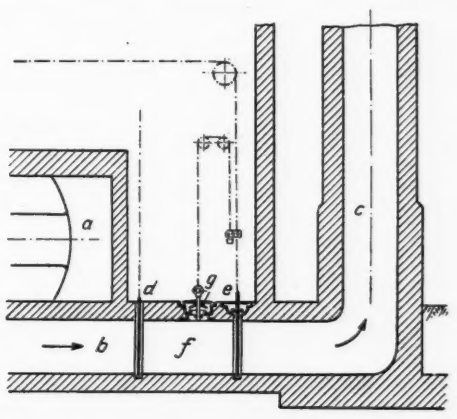
If in 3 we substitute this expression for P it will be found to be identical in form with 2.

From a practical point of view 2 is more convenient than 3 as it is generally much easier to determine the charge pressure than the temperature. The main use of the formulas is that the effect of alterations to one or more of the factors is brought out clearly.

Shutdown Losses Decreased

INVESTIGATIONS by Praetorius, Ebel and others, reported in the German publication, Arch. f. Waermewirtschaft, have shown that there are some shutdown losses due to radiation and conduction from the boiler and furnace walls. The great losses in standby boilers and furnaces are caused by cooling due to chimney draft, leaky fire doors, leaky chimney dampers, leaky walls, etc.

Dampers arranged as developed by the Enzinger-Union-Werke, Mannheim-Berlin, have been found effective in saving heat. Referring to the illustration, the boiler *a* is connected to the chimney *c* through the flue *b*.

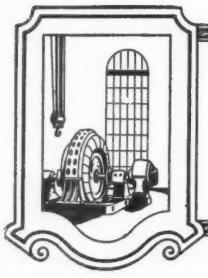


DRAFT STOP OF THE ENZINGER-UNION-WERKE, MANNHEIM, BERLIN

During the shutdown period the usual chimney damper *d* and the safety damper *e* divide off in the flue chamber *f*. This chamber connects with the outside through the air valve *g*. When the two dampers close, the valve is opened automatically by a pulley and chain connected with the dampers.

When the two dampers are closed and the valve is open, no air can be drawn through the boiler, even if the chimney damper *d* should be open. Should the safety damper not fit tight, then air is drawn through the chimney from the valve *g*. In either case, the boiler is completely cut off from the chimney; therefore there is but little cooling of the chimney and of the flue passage between the safety damper *e* and the chimney. To decrease the losses to the minimum, the safety damper is specially cast and makes a close fit. Furthermore, the safety damper may be placed close to the chimney damper to prevent the entire flue from cooling.

Operation of this arrangement does not affect the usual boiler operations. Its installation results in the protection of the brickwork against temperature variations. Heat is saved and economies are also effected by the shortening of the heating-up time.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

The Reactive Component in A. C. Circuits*

PART II. THE EFFECT OF POOR POWER FACTOR ON VARIOUS TYPES OF APPARATUS. BY V. E. JOHNSON

IN CONSIDERING THE effect of the reactive component on the generation and transmission of power, it will be convenient to consider each element of the transmission line separately, beginning with the generating unit.

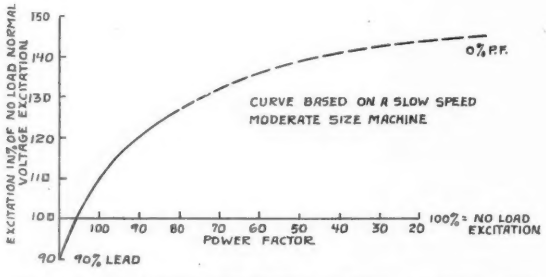


FIG. 1. RELATION BETWEEN POWER FACTOR AND EXCITATION

A generating unit consists essentially of:

A. The generator itself, with its source of excitation.

B. The prime mover as engine or turbine.

C. The auxiliaries.

D. A portion of the boiler capacity, dam capacity, or similar source of energy.

Cost considerations require that these component parts be so rated that their maximum output is reached simultaneously. This rating is based upon various design dimensions and operating conditions, and is measured in terms of useful energy output, except in the case of the generator itself, in which the capacity is limited primarily by the operating temperatures to which the windings may safely be subjected, regardless of the actual kilowatt output.

It is evident that with a normally proportioned unit, a serious economic loss results if loads of low power factor cause the generator to reach its safe limit much in advance of the other component apparatus.

Example: Assume a 5000-kw. turbo-generator unit supplying a load at 50 per cent power factor. The generator will reach full load at 2500 kw., limiting the output of the entire group to ½ of its rating and virtually doubling its installed "per kw." cost.

It is, however, standard practice to provide for the circulation of some wattless current by over-rating the generator—designing it for operation at 80 per cent power factor. This is equivalent to installing 25 per cent additional current capacity and of course adds to the cost but permits higher loads on the balance of the equipment.

Example: The unit in the previous example would ordinarily have a generator rated at 80 per cent p.f. or 6250 kv.a. At 50 per cent power factor its limiting output would be 3125 kw., or a little over 60 per cent of the group rating.

In addition to the very evident reduction in economic unit ratings due to reduced kilowatt output of generators as in the previous examples, there is a marked relation between the performance of a machine and the phase relations established by its load. The wattless component has considerable effect on the excitation required to maintain constant terminal voltage, lagging or leading current necessitating respectively an increase or decrease in the field current. The curve in Fig. 1 shows this graphically.

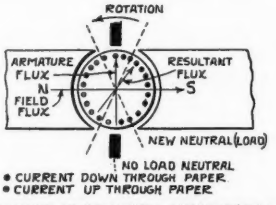


FIG. 2. DIRECT CURRENT ANALOGY TO UNITY POWER FACTOR

A rigid analysis of the causes of this phenomenon is beyond the scope of this discussion, but the governing conditions are closely analogous to those which exist in a direct current armature with various loads and brush positions.

In the latter, with the brushes at "neutral," the load current reduces the terminal voltage by distorting the field flux; this distortion is due to the armature magnetism combining with that of the main field and forming a new neutral line displaced in the direction of rotation. This is shown in Fig. 2.

If the brushes are shifted in the direction of rotation, as indicated in Fig. 3, the terminal voltage will be still further reduced, due to the fact that the arma-

*This is the second of a series of articles on this subject by the same author. The first appeared in the Feb. 1 issue.

ture flux will now have a demagnetizing component which is directly opposed to the field magnetism. On the other hand (commutation permitting), if the brushes are shifted backwards, against the direction of rotation, the tendency will be to increase the voltage, due to the magnetizing component.

Applying this analogy to an alternator, it is found that the first condition above (with the brushes at neutral) corresponds to unity power factor operation; the stator current distorts the flux and causes some drop in voltage. Advancing the brushes is equivalent to delaying the current carrying conductors, and compares to a.c. operation with lagging currents; a demagnetizing component of the flux directly opposes the field. Retarding the brushes approximates, in effect, the conditions in an alternator delivering leading current; a magnetizing component directly in phase with the rotor flux tends to raise the terminal voltage and may, in fact, increase it above normal.

This action of the stator currents in setting up a magnetism which combines with the main flux is known as "armature reaction." It varies with the value and phase relations of the load. Inasmuch as the field losses are proportional to the square of the current, it follows that any increase in excitation is accompanied by a rise in rotor temperature, and a consequent reduction in the safe output. Therefore, operation at lagging power factor decreases the capacity by increasing the field heating, while leading power factors have the opposite effect.

From the standpoint of heating due to copper losses in the stator, it is immaterial whether the current leads or lags, but taking into consideration the field conditions, the former is preferable. Maximum output being limited by the hottest portion of a machine, it is generally true that unity power factor permits the heaviest loading; any saving in excitation due to leading currents is ordinarily more than offset by the increase in stator losses.

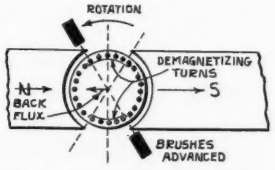


FIG. 3. DIRECT CURRENT ANALOGY TO LAGGING POWER FACTOR

An interesting limiting case is that in which the leading currents required to charge a long transmission line cause the alternator under certain conditions of design and operation to become self exciting.

Figure 4 shows vector diagrams covering the operation of alternators at various power factors. It will be seen that in A, B and C the internal drop becomes successively greater, with a consequent necessary increase in the excitation required to maintain constant terminal voltage.

As a corollary to the fact that the total generator losses are lowest at unity power factor, it follows that the electrical efficiency is highest and that the greatest kilowatt output permits better prime mover economy.

Summary of Effects on Generating Units

Low power factor has the following effects on the performance of a generating unit:

A. It reduces the capacity of the generator.

B. It wastes a portion of the unit capacity.

C. It causes an increased demand for exciting current and so requires a greater investment in exciters. (This is not true when the wattless currents are leading, but in general this condition does not enter very seriously into the problem of power factor.)

D. It causes poor regulation.

E. It reduces the efficiency of the generator.

F. It reduces the efficiency of the prime mover.

Transformers

Limitation of kilowatt output of a transformer is a function of the power factor of its load, in a manner somewhat analogous to that of generating units previously discussed. The loss in rating is, however, confined to the unit itself, as there is no auxiliary apparatus to increase costs due to idle capacity.

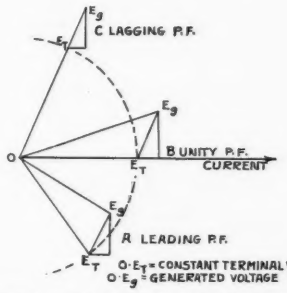


FIG. 4. RELATION IN GENERATOR UNDER VARIOUS POWER FACTORS

The regulation of the transformer is affected by the value of the wattless component of the load current, increasing as the angle of displacement becomes larger. Figure 5 shows in tabular form the effect of power factor on the regulation of a number of sizes, while Fig. 6 shows the vector relations involved.

It will be noted that the internal drop becomes successively greater in A, B and C, so that with a constant primary pressure, the secondary voltage decreases. This bad regulation may necessitate the use of separate transformers for lighting—an added expense directly chargeable to low power factor.

For a given kilowatt output the losses in a transformer are lowest at unity power factor, so that for inductive loads the efficiency of transformation suffers.

Summary of Effects on Transformers

Low power factor has the following effects on the performance of a transformer:

A. It reduces the kilowatt output.

B. It increases the regulation, with a consequent bad effect on the service.

C. It reduces efficiency by increasing the losses per kilowatt of output.

A transmission line or feeder supplying a given kilowatt load operates most economically at 100 per cent power factor. Calculation will show that to transmit a certain amount of energy with a given line loss will

require approximately twice as much copper at 70 per cent power factor as at unity.

Example: Assume a 3 phase load of 100 kw. at 200 v. For various power factors the kv.a. and current would be as follows:

Power factor (per cent)	100	90	80	70	50
Kv.a.	100	111	125	143	200
Current	288	320	361	413	577

Losses vary as the square of the current, so that between unity and 70 per cent the ratio would be $288^2/413^2$ which is approximately ½. At the comparatively high power factor of 90 per cent the losses are increased in the ratio of $320^2/288^2$ or about 25 per cent.

ALL SINGLE PHASE	RATING KV.A.	REGULATIONS PRI. V.	100% P.F.	80% P.F.
	10	2300	1.80	2.70
	100	2300	1.30	3.15
	10	33,000	3.00	5.00
	100	33,000	2.00	6.00
	1000	6,600	1.00	4.00
	1000	66,000	1.30	5.50

FIG. 5. TRANSFORMER REGULATION (60 CYCLE)

load voltage E_L, the generated pressure E_g must vary with the power factor, passing from a maximum at 0 per cent lagging, to a minimum at 0 per cent leading.

The effect of poor lagging power factor on the regulation of a transmission line is therefore two-fold. For a given kilowatt load, the increase in amperes required produces a larger impedance drop; this drop in turn comes into almost direct opposition to the generated voltage as the phase angle approaches 90 deg. On the other hand, with low leading power factor, the impedance drop tends to help the supply voltage.

On short conductors, and on buses and switches, the principal disadvantage of low power factor, either lead-

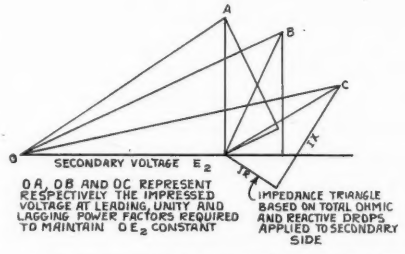

A
B
C
IX
O
SECONDARY VOLTAGE E_2
IR
OA, OB AND OC REPRESENT RESPECTIVELY THE IMPRESSED VOLTAGE AT LEADING, UNITY AND LAGGING POWER FACTORS REQUIRED TO MAINTAIN OE_2 CONSTANT
IMPEDANCE TRIANGLE BASED ON TOTAL OHMIC AND REACTIVE DROPS, APPLIED TO SECONDARY SIDE

FIG. 6. ELEMENTARY REGULATION DIAGRAM

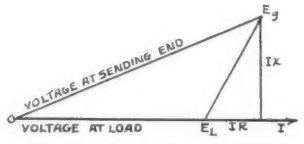


FIG. 7. LINE DROP AT UNITY POWER FACTOR LOAD

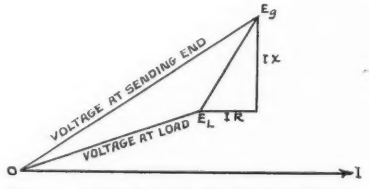


FIG. 8. LINE DROP WITH LAGGING P. F. LOAD

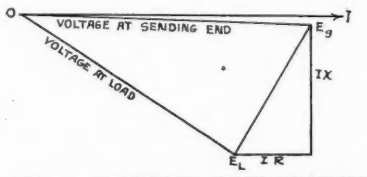


FIG. 9. LINE DROP WITH LEADING P. F. LOAD

The copper required to keep the losses constant would be proportional to the squares of the currents, so that at 90 per cent and 70 per cent, respectively, the amount would be 125 and 200 per cent of that needed at unity.

Effect of Transmission Line Inductance

If a transmission line had no inductance, the line drop would be proportional to the current and resistance (IR) regardless of the phase relations of the load. This is, however, a theoretical condition seldom met in practice, for any conductor in which current is flowing is surrounded by a magnetic field. With commercial spacings these fields are not cancelled out to any appreciable extent, so that the inductive voltages must be considered in calculating the performance of circuits of even moderate length.

Figure 7 shows the relations between the current and voltage in a transmission line having a resistance R and a reactance X. With a current I flowing, the ohmic and reactive drops will be IR and IX, respectively, the angular positions being as indicated. A load of such a nature as to require a terminal voltage OE_L in phase with I, could be supplied only by a generated voltage E_g at the supply end, equal to the vector sum of OE_L, IR and IX. If the load itself had reactance so as to produce a phase displacement between current and voltage, the vector diagram would be as in Fig. 8 and Fig. 9. It will at once be seen that for a constant value of the ing or lagging, is that it reduces the kilowatt transmitting capacity by increasing the number of amperes per watt. The effect on regulation is negligible.

Summary of Effects on Conducting Apparatus

Low power factor has the following effect on conducting apparatus:

A. It reduces the kilowatt transmitting capacity by increasing the number of amperes per watt.

B. In transmission lines and feeders it increases the regulation, first—by increasing the current for a given kilowatt load, and second—by changing the phase relations that exist between the impedance drops and the load terminal voltage. The latter effect will, however, help the voltage when the load power factor is leading.

C. Regardless of whether the power factor leads or lags, the losses will be increased due to the increase of current.

D. The increased losses and poorer service may require additional investment in copper or in other corrective measures.

General Summary of the Effects of Low Power Factor

An excessive wattless component of the load current affects the characteristics and operation of a system as follows:

A. By increasing the amperes per kilowatt, it reduces the power capacity of generators, transformers,

switching equipment, feeders and transmission lines, thus necessitating the installation of larger apparatus than would otherwise be necessary.

B. It increases the losses due to the necessity of circulating more current per kilowatt, and so reduces operating efficiency. The additional losses also requires larger equipment to care for them.

C. It increases the losses due to the fact that prime movers and other apparatus must operate at inefficient loads.

D. It has an adverse effect on voltage regulation, with consequent poor service. This in turn leads to reduced output of industrial equipment, spoilage and many other related losses.

Obtaining Sparkless Commutation

ORDINARY SPARKING TROUBLES EASILY CORRECTED IF CARE IS TAKEN IN ANALYZING THEIR CAUSE AND APPLYING PROPER REMEDIES. BY E. J. MORRISSEY

TO CORRECT SPARKING of brushes, an engineer should be thoroughly acquainted, not only with the distinguishing types of sparking but with the inherent cause of sparking.

All operators, particularly the old timers or attendants to continually overloaded machines, are well acquainted with many types of sparking. Nearly everyone will readily recognize the vicious sparking caused by an open commutator riser or armature coil, the green spit of burning copper, the ring fire of dirt, the glowing of overloaded or badly set brushes or a mixture of the above from general causes.

There is no excuse for sparking in properly designed machines operating within reasonable limits or overloads to a certain extent, and a great majority of modern machines will stand much abuse before sparking becomes a dangerous item.

Many attendants fail to recognize the necessity for proper brush fitting or tension; fitting is essential to service and tension for current-carrying ability. The best fit in the world is worthless without tension and a ton of tension is of little or no value to a brush riding on a point.

Sustained overloads are often a cause of sparking and here the remedy is obvious. Short overloads of reasonable magnitude can be carried to the point where temperature of contact surface rises, causes contact resistance to lower, which takes about 20 min. to reach full values.

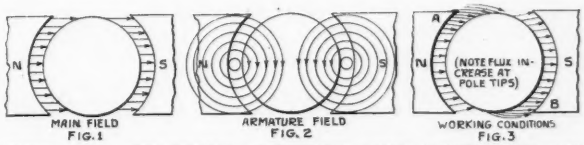
In any normal machine the tendency to spark at the brushes is proportional to the current in the coil under commutation, the inductance of the coils, the number of coils simultaneously commutated by one brush and the number of coils in series between positive and negative brush. Time enters into account also but is inversely proportional to length of time a coil is short circuited by a brush.

In considering armature reaction, we should also consider its cause; to do so, we must take into account the flux from the main and armature fields. The main field, Fig. 1, or armature field, Fig. 2, acting alone might be considered uniform in every respect but when acting together under load conditions we find a tendency for flux to increase at pole tips "A" and "B" and to decrease at the other pole tips, Fig. 3.

Armature reaction can be overcome by three principal means: resistance, brush shifting, and interpoles, the last being the most universally used in present day design.

Resistance commutation operates through the principle of large brush contact resistance in comparison to the self-induction and resistance of the coils under commutation, with the result that the current divides in proportion to the areas of contact between brushes and segments giving a uniform current density across the brush.

Brush shifting is another means of controlling com-



FIGS. 1-3. DIAGRAMS SHOWING THE DIRECTION OF FIELDS IN D. C. MACHINES FOR VARIOUS CONDITIONS

mutation in which the brushes are shifted to the point of no sparking at the various loads and in so doing the brush merely follows the distorted field to point of proper commutation. In shifting, the brushes are rotated forward or backward as the case may be until the flux fringe of the adjacent coil furnishes enough counter magneto motive force to overcome the value of induction in the coils under short circuit. To shift too far would pick up too much magnetomotive force opposite in value to that which we desire to correct and sparking would develop in proportion to the overvalue.

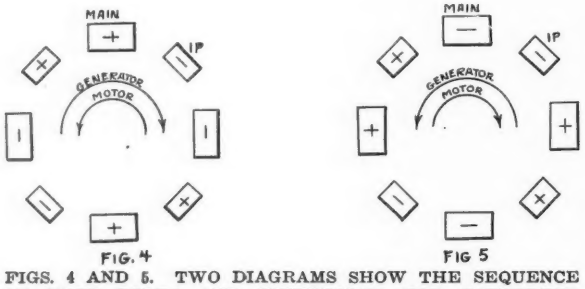
USE OF INTERPOLES

Of the various methods of correcting armature reaction, the use of interpoles is the most universal and most satisfactory of any method yet devised. Interpoles are small coils similar in respect to series coils and so designed as to handle loads approximating 50 per cent overload before they become saturated. This gives them ample latitude under all conditions, proportional to the loads as the interpoles are in series with the series field and armature. Their field intensity varies with the load and their function is to provide enough counter magnetomotive force to overcome the value of induction of the coils under commutation.

Proper connections of interpole fields are shown in Figs. 4 and 5, but this connection is usually made permanently in the factory and the necessity of changing comes only to meet special requirements or assembly after general overhauling. When once set, brushes should not be changed on machines having interpoles. Excessive interpole force manifests itself in sparking in

practically the same manner as a brush being shifted too far on non-commutating pole machines.

Properly designed interpoles will have field strength of sufficient value merely to counteract the value of self-induction in coils under commutation. If voltage measurements are taken during operation they will show an equal voltage drop at all points of the brush. To make this measurement a pilot brush is used to give values at each end and middle of brush contact or if more accurate measurements are desired, the contact surface is divided into 10 equal divisions and readings taken at all points to note distribution, as shown in Fig. 6A.



FIGS. 4 AND 5. TWO DIAGRAMS SHOW THE SEQUENCE OF MAIN POLES AND INTERPOLES FOR DIFFERENT DIRECTIONS OF ROTATION

In this article, for simplicity we will consider the former method and referring to Fig. 6A, we note equality of drop at X-Y-Z, Fig. 6B. If we find a high voltage drop at X and either a low drop or reversal at "Z" our interpole field is too strong: If this reading proves of opposite nature giving a low or negative reading at "X" with high drop at "Z" our interpoles are weak. A differential voltmeter 3-0-3 will prove handy in making this test and one connection is made permanently on the brush arm and the other held on the commutator at desired position, Fig. 6C.

I have found a battery testing voltmeter handy in making this test and instead of using the ordinary spike for commutator two other means are available, the pilot brush or an ordinary lead pencil. The pilot brush can be made of wood or other insulating material with small carbon brushes used for contact to commutator. as shown in Fig. 6D.

Interpole strength can be changed by removing or adding packing to the frame where it it attached, removing packing tending to lower its value and adding packing to increase its value.

Obviously, these tests are more of a field nature than of a standardizing laboratory but they can be elaborated upon to give excellent results.

Selection of Brushes

High mica is too often the cause of sparking in brushes; a high mica is quite often the result of using a brush not abrasive enough and sometimes the result of a mica too hard for commutator building.

A hard brush is not necessarily an abrasive brush and extreme care should be exercised in selecting proper brushes for a particular generator.

Present day practice favors the under cut mica which I believe commendable in the majority of commutators. To cut too deep makes dirt a determining factor in commutation. To cut improperly will give high mica trouble and opinions are divided as to the merits of the square or "V" type of mica undercutting. The square cutting proves the best with dirt gathering ability of paramount consideration and while the "V" type does not gather so much dirt it does allow a side mica to be given consideration.

Another cause of sparking in commutators and generally the result of repair work is the use of poor grade copper in making commutator bars.

Only the best copper should be used for commutator bars as cast copper has the disadvantage of as much as 20 to 25 per cent lower current carrying ability, which means heating, as well as blow holes and impurities of a detrimental nature. Manufacturers guard against this but it should also be just as surely guarded against on repair work as a commutator is very expensive both in first cost and in repair.

About the only remaining general cause of sparking is brush setting; this applies to spacing around the commutator, alinement on the commutator bars and neutrality. Spacing around the commutator can be accurately measured with paper ribbon or approximately accurately by counting bars.

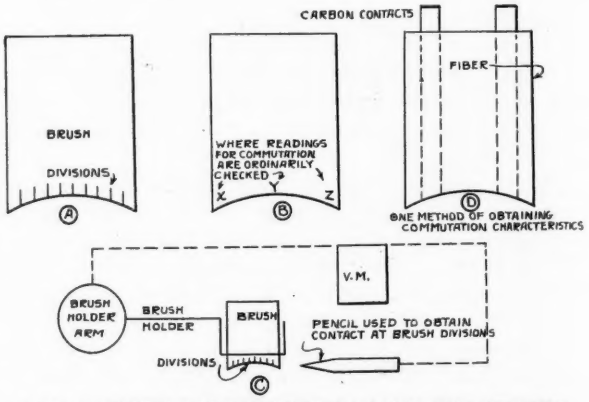


FIG. 6. ILLUSTRATING METHODS OF BRUSH TESTING

Alinement is just as essential lest brushes cover too many bars, which will give the same results as using a brush too wide.

Neutrality of brushes can be determined in various ways, the practical method being to shift the brushes back and forth until sparking disappears but this is only approximately accurate as commutation may be poor without visible sparking.

In properly set brushes the shunt windings should be excited from a low voltage source with a switch in circuit. Connect a low reading voltmeter to the armature brushes and break the field connection with the switch. This will cause a "kick" in the voltmeter and shifting of brushes should be accomplished until this voltmeter kick disappears or is at a minimum.

Other methods can be used. In a motor, run the machine at constant excitation and shift brushes for minimum speed; in a generator, shift the brushes until a maximum voltage reading is obtained in a voltmeter connected across brushes.

This concludes a general resume of sparking. There are many other causes that could be enumerated but

an attempt to do so would necessitate writing a treatise, tiresome to the average reader of this magazine.

I believe that the majority of cases can be corrected by any intelligent operator.

It is a sad fact that many operators do not stagger their brushes and thereby abuse their commutators; others fail to fit a brush properly, allow a commutator to become dirty or everlastingly peck away at it with stones and sandpaper until it looks like a spanked baby.

A good commutator has a rich brown color and is true in rotundity and service. A high gloss may be found detrimental due to its resistance but is preferable to a raw, red or jet black commutator that is noisy and fearsome to behold. In most cases, a commutator reflects the service given it.

First Aid for Eye Injuries

By B. Franklin Royer, M. D.*

THERE ARE three cardinal principles of first aid after eye injuries. The first of these is cleanliness; next, prompt rest for the eye; and, third, medical care directed by a competent physician, preferably an oculist. These principles apply even if the injury is slight, and they are imperative with serious eye injuries.

In removing dirt, it is a common custom to lift the upper lid and to push the lower lid with its lashes over the eyeball well up under the upper lid and then to draw down the upper lid. This procedure often enables the lashes of the lower lid to drag out of the eye a bit of dirt or rough material that may be causing great annoyance. The method, however, has all the possibilities of introducing an equally annoying amount of dirt and, what is worse, of sometimes introducing directly from the soiled lashes germs that may find an ideal place to grow in the freshly scratched tissues from which the dirt was removed.

Cleanliness, then, is the first thing to think of. Refrain from pushing the lashes under the lids until the lashes have been washed and be sure that the fingers which are going to handle the lashes and lids are also thoroughly washed. Be sure that the medicine dropper or eye-cup that may be used has been thoroughly cleansed.

A rough bit of dirt blown into the eye may be comparatively harmless if removed quickly and carefully, but, with rough manipulation through rubbing of the lids, the dirt may actually be driven into the tissues of the eye or may cause numerous scratches on the lining of the lids or of the conjunctiva covering the eyeball. Broken surfaces are thus exposed to all sorts of infection and abundant opportunity is given for germs to be carried into the eye tissue with the original particle of dirt.

Make no attempt to remove particles of dirt from the eye until the hands and lashes have been thoroughly cleansed. Next, take a little twist of the cleanest of absorbent cotton, either twisted tight upon its own fibers with a little tufted tail piece, or twisted about a matchstick with a little tuft extending from the end. Separate the lids and note the location of the thing to be removed. With the prepared cotton it is usually safe very gently to drag the tail piece over the thing to be removed. The cotton drags it out. If no cotton is available and the dirt is on the inside of the upper lid, then, after cleansing the lashes, the under lid may be pushed up under the upper lid which should then be drawn down quickly affording an opportunity to drag out the dirt with the lashes of the lower lid.

The corner of a perfectly clean handkerchief fresh from the laundry may be used like this cotton twist in removing dirt.

Many eyes are infected and some lost because of the introduction of germs from dirty hands, dirty handkerchiefs, dirty lashes, or dirty materials used in attempting to do the kind thing for the individual suffering with dirt in the eye.

If much scratching occurred during removal of dirt or if dirt has been in the eye for a considerable length of time, great comfort may be had by gently placing a piece of soft linen that has been boiled and wet with cold water, over the eye and then very lightly bandaging the eye. This places the eye at rest, makes easier lifting lids from eyeball by the tears, and favors start of the healing process. This is a good procedure to follow until such time as medical advice may be secured.

In graver injuries, where flying particles may have been driven into the eye tissues and injured the outer covering of the eyeball, it is wiser immediately to cleanse the outer surface of the eye, lashes and lids, place a wet dressing over the eye with a light bandage and secure forthwith medical opinion as to the best method of procedure.

Dirty habits, such as removal of things from the eye by utilizing a matchstick that has been carried in the smoker's pocket for a long while, have been largely discarded. In modern factories and mills nowadays instruction is given to employes in first aid, and at convenient points throughout the plant, first aid equipment stations are maintained with clean, sterilized materials such as are used in an operating room always available.

By closing the eyelids until a good flow of tears accumulates under them, and then blowing the nostrils hard on the side toward the eye in which the dirt is located, one may often wash the irritating bit of dirt down the nose.

It sometimes happens that an acid burn of the eye is sustained. It is safe immediately to wash the acid-burned area with an alkaline solution made by adding half a teaspoonful of ordinary baking soda (bicarbonate of soda) to half a glass of water, or, in the absence of water, one may put a little of the dry powder into the eye. Introduction of the powder may not be quite comfortable but it will retard the deep burn and in most instances will be soothing.

All first aid stations stick to the cardinal principles of cleanliness, doing no hurt and placing the eye at rest.

*Medical Director of the National Committee for the Prevention of Blindness.

According to the latest report of the Geological Survey, Department of the Interior, production of electric power by public utility power plants in the United States for November, 1927, reached a total of 6,860,200,000 kw-hr., an increase of 6 per cent over the output of November, 1926. Of this amount 4,361,453,000 kw-hr. were generated by fuels and 2,498,747,000 kw-hr. by water power.

Riverside Station Adds a 15,000-Kw. Unit

RECENT ADDITION TO PLANT AT SAVANNAH, GA., IS INDEPENDENT OF OLD STATION EXCEPT FOR ELECTRICAL CONNECTION AND STEAM CONNECTION. IT OPERATES AT 400 LB., BURNS EITHER PULVERIZED COAL OR OIL IN WATER-COOLED FURNACES AND HAS SEPARATE FUEL HANDLING SYSTEM

IN THE SPRING of 1926 the Savannah Electric and Power Co., which supplies electric light, power and street railway service to Savannah, Georgia, and several adjacent communities, was without adequate dependable capacity to supply the anticipated winter peak load. The company had three steam power plants, the largest of which was the Riverside station with a capacity of 13,000 kw., and two smaller ones, which were older and were used for stand-by service only.

With the object of reducing the cost of operation to a point comparable with the most modern central stations, it was decided to provide in the Riverside station boilers, turbine and generator large enough to carry the anticipated peak load for the next two or three years and to use the existing plants as a relay to the new equipment. In carrying out this decision there were installed two of the latest type 400-lb. pressure, 1370-hp., Babcock & Wilcox boilers, equipped with water-cooled furnace walls, a 15,000-kw. General Electric Co. turbo-generator with a surface condenser and the necessary auxiliaries.

Old boilers were equipped with oil burners, but investigation disclosed that coal could be purchased, delivered, stored, pulverized and burned in the new boilers more economically than oil at the existing market prices. To obtain this additional economy a complete coal handling and storage system was included with duplicate unit pulverizers for each boiler. Burners were selected for the pulverized coal which could be readily adapted to burn fuel oil.

The new extension is entirely independent of the old station except for the electrical connection to the distributing system and a steam connection to permit the new boilers to supply steam to the old turbines.

This addition to the Riverside Station was designed and constructed by Stone & Webster, Inc.

Principal Equipment in Addition to Riverside Plant, Savannah Electric & Power Co.

GENERAL

Location	Savannah, Ga.
Character of service	Local power, light and street railway
Capacity—old plant	13,000 kw.
Capacity—extension	15,000 kw.
Total capacity	28,000 kw.
Dimensions—boiler room extension	56 by 105 ft.
Dimensions—turbine room extension	55 by 49 ft.
Dimensions—electrical bay extension	26 by 47 ft.

COAL HANDLING EQUIPMENT

Unloading, storing and reclaiming equipment (50 t. per hr)	Stephens-Adamson Mfg. Co.
Coal conveyors (50 t. per hr.)	Robins Conveying Belt Co.
Coal crusher (60 t. per hr.)	American Pulverizer Co.
Coal hoppers and spouts	The Walsh & Weidner Boiler Co.
Weigh larry (3-t. capacity)	Jeffrey Mfg. Co.
Unit pulverizers and blowers (7000 lb. per hr.)	Riley Stoker Corp.
Pulverized coal burners	Peabody Engineering Corp.

BOILERS AND SUPERHEATERS

Boilers (vertical header, cross drum)	The Babcock & Wilcox Co.
Superheater (interdeck, convection)	The Babcock & Wilcox Co.
Water walls (Bailey block type)	Bailey Meter Co.
Water wall insulation	Johns-Manville Corp. of Mass.

CHIMNEY AND DRAFT EQUIPMENT

Chimney (reinforced concrete) 12 ft. 6 in. inside diameter at top, 250 ft. high, lining 50 ft. high	General Concrete Const. Co.
Smoke flues, breeching and air ducts	The Walsh & Weidner Boiler Co.
Forced draft fans (45,000 c.f.m.)	B. F. Sturtevant Co.

ASH HANDLING EQUIPMENT

Ash hoppers (ventilated steel plate)	Connery and Co., Inc.
Ash gates, clinker chambers, and sluiceway	Allen-Sherman-Hoff Co.
Locomotive crane (½-cu. yd. bucket)	Industrial Works

PUMPS

Boiler feed pumps (two 500 g.p.m.)	Worthington Pump & Mach. Corp.
Ash sluicing pumps (one 1000 g.p.m.)	Ingersoll-Rand Co.
Air cooler pumps	DeLaval Steam Turbine Co.
Evaporator pumps	M. T. Davidson Co.

MISCELLANEOUS BOILER ROOM EQUIPMENT

Deaerator (170,000 lb. per hr.)	Elliott Co.
Evaporator equipment (7500 lb. per hr.)	Griscom-Russell Co.
Feed water heater (5th stage)	Elliott Co.
Boiler feed water regulators	Stets Co.
Soot blowers	Vulcan Soot Cleaner Co.
Soot removal equipment	Conveyors Corp. of America

PRIME MOVERS

Turbine (1800 r.p.m., impulse type)	General Electric Co.
Generator (15,000 kw., 80 per cent p.f., 13,200 v., 3 phase, 60 cycle)	General Electric Co.
Generator air cooler	General Electric Co.
House turbo-generator (500 kw., 80 per cent p. f., 2300 v., 3 phase, 60 cycle)	Westinghouse Elec. & Mfg. Co.

CONDENSER AND AUXILIARIES

Surface condenser (25,000 sq. ft.)	Wheeler Cond. & Eng Co., now Foster Wheeler Corp.
Condenser tubes	British American Tube Co.
Air removal (2 steam jet units)	Foster Wheeler Corp.
Circulating water pumps (19,000 g.p.m.)	Foster Wheeler Corp.
Condensate pumps (400 g.p.m.)	Foster Wheeler Corp.
Traveling intake screen	Chain Belt Co.

MISCELLANEOUS

High pressure gate valves, high pressure piping, circulating water valves	Pittsburgh Valve, Foundry and Construction Co.
Blowoff valves	The Babcock & Wilcox Co., Everlasting Valve Co., Yarnall-Waring Co.
Safety valves	Consolidated Safety Valve Co.
Circulating water piping	Lumsden & Van Stone Co.
Valve control equipment	Liberty Electric Corp.

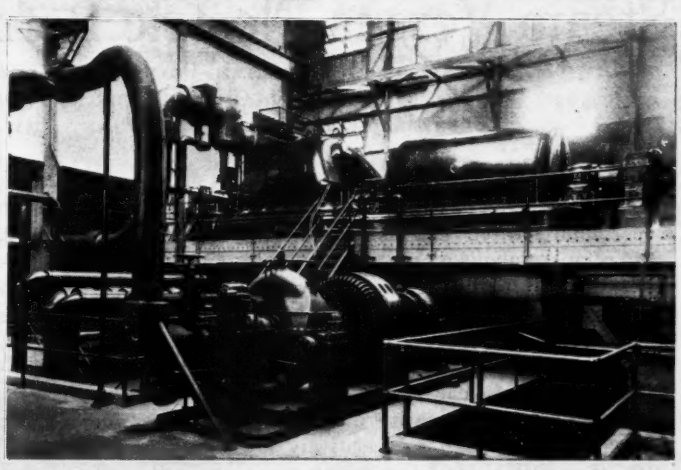
ELECTRICAL EQUIPMENT

Oil circuit breakers	General Electric Co.
Motor starting equipment	General Electric Co.
Motors	General Electric Co. and Westinghouse Elec. & Mfg. Co.
Disconnecting switches and fittings	Electric Power Equip. Corp.
Station service switchboards	Westinghouse Elec. & Mfg. Co.
Main control switchboard	Condit Electric Mfg. Co.
Main control switchboard instruments	General Electric Co.
Excitation switchboard	General Electric Co.

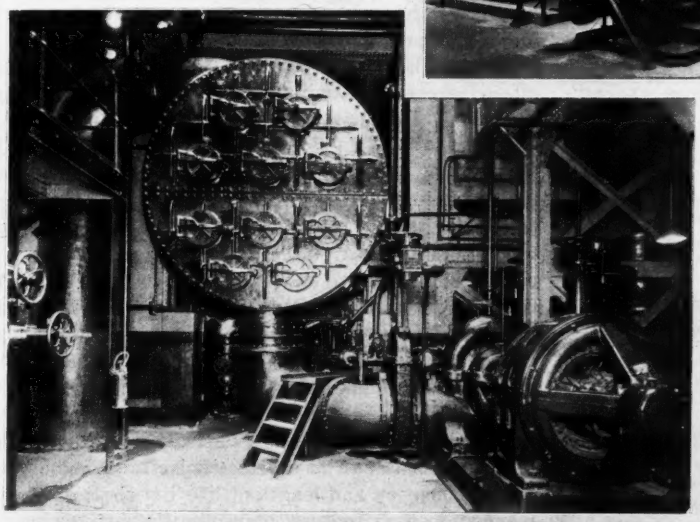
POWER PLANT INSTRUMENTS

Draft gages	Bailey Meter Co.
Flow meters	Bailey Meter Co., Builders Iron Foundry
Indicating pressure gages	The Foxboro Co., Inc., Crosby Steam Gage & Valve Co.
Master steam gage	Star Brass Co.
Recording temperature and pressure gages	Bailey Meter Co., The Foxboro Co., Inc.
Thermometers (mercury)	American Schaeffer & Budenberg Corp.
Thermometers (dial)	The Foxboro Co., Inc.

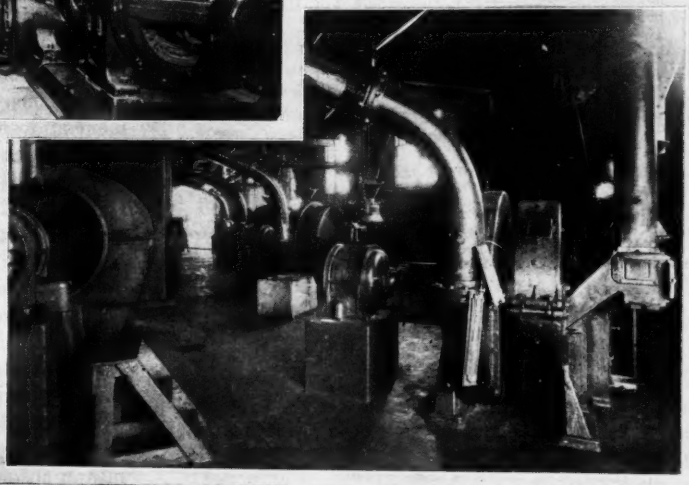
Views of New Equipment at Riverside Station, Savannah, Georgia



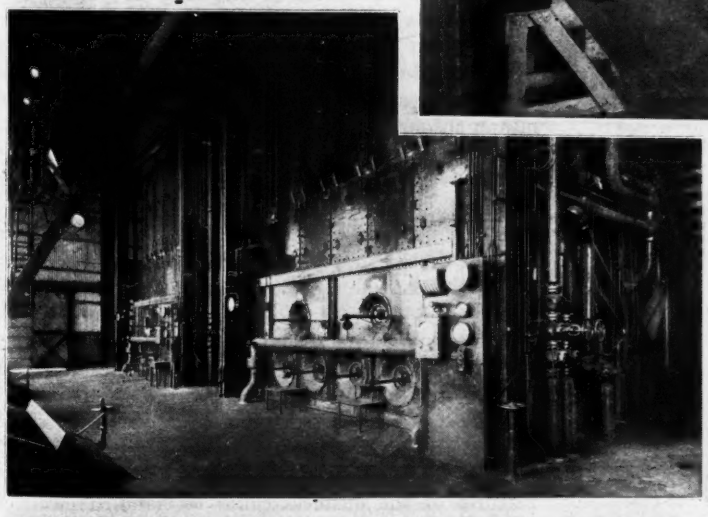
Above—New 15,000-kw. unit takes steam at 400 lb. pressure. In the foreground is the 500-kw. house generator.



Left—A 25,000-sq. ft. surface condenser, with circulating pumps and other auxiliaries serves the new unit.



Right—To serve the two new boilers, unit pulverizers of 7000 lb. per hr. capacity are installed. Coal is handled by a system separate from that of the old plant.



Left—Old boilers were equipped with oil burners and two new 1370-hp. boilers with combination oil and pulverized coal burners, so that most economical fuel can be burned. New boilers have water-cooled furnaces and can serve old turbines through reducing system if necessary.

Steam Versus Electric Refrigeration Plants

ALTHOUGH THE STEAM PLANT HAS A HIGHER VOLUMETRIC EFFICIENCY THIS IS OFFSET BY THE MANY OTHER ADVANTAGES OF THE ELECTRICALLY DRIVEN PLANT. BY W. R. WOOLRICH*

FOR THREE DECADES the most popular prime mover in the refrigeration plant was the Corliss engine. Ice manufacturers and operating engineers had learned to compare plants on the basis of the production of tons of ice per ton of coal burned at the boiler, and such a comparative basis was generally accepted as the practical standard.

Unfortunately, the size of nearly all steam driven plants was small. This made it advisable to install non-condensing units in the majority of plants. The relative performance economy was relatively low, but the simplicity of operation and low maintenance expenditures of the low speed Corliss drive made it a favorite with both manufacturers and users.

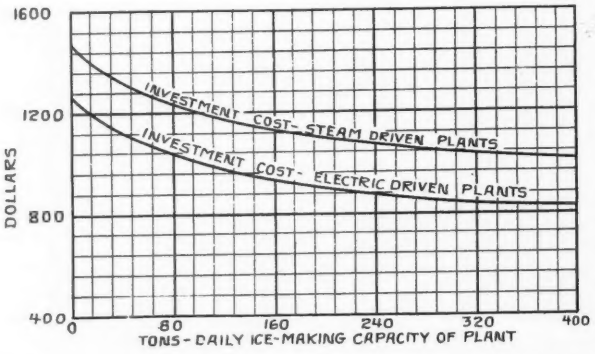


FIG. 1. COMPARISON OF COST OF COMPLETE ICE PLANT PER TON OF ICE-MAKING CAPACITY WHEN EQUIPPED WITH STEAM AND ELECTRIC DRIVE

Example: A 200 ton daily ice capacity steam driven plant will cost approximately $1100 per t. installed or $220,000 total. The same plant electric driven will probably cost $900 per t. or $180,000.

With the long stroke, slow speed, steam driven units, high volumetric efficiencies were readily obtained. The fundamental equation for net volumetric efficiency of ammonia compressors is made up of two component efficiency factors, which in equation form reads:

$$E_v = E_s \times E_c$$

In which

E_v = Net volumetric efficiency.

E_s = Volumetric efficiency computed on the basis of the effective superheating during compression.

E_c = Volumetric efficiency computed on the basis of the clearance.

Interpreted, then, this formula states that the net volumetric efficiency is equal to the product of the volumetric efficiency due to superheating, and the volumetric efficiency due to clearance. The superheating effect is usually greater on high speeds than on low speeds, and this gives then, higher values of E_s for slow speed machines.

The ratio of the clearance volume to the total cylinder volume is greater on short stroke than long stroke machines and this gives a higher value to E_c on the long stroke machine.

Any attempt to change, then, from slow speed steam driven units to the high speed electric driven units has to be made with some sacrifice in net volumetric efficiency of the machine, as both E_s and E_c are lowered in value.

Fortunately, for the designers of high speed ammonia compressors, vertical single acting machines can be used. The vertical single acting machine has always offered greater possibilities for high volumetric efficiencies than the horizontal double acting ammonia compressor.

Vertical machines could be made with false heads, and thus permit very small clearances, but the horizontal double acting machine could not be easily designed to meet these conditions. While the steam driven machine designers have met this situation by using vertical compressors with horizontal engines, it has involved an expensive construction.

Thus, while the vertical slow speed, single acting, steam driven ammonia compressor has given high volumetric efficiencies, the machine cost has been high, and usually the steam economy relatively low. Its electrical competitor has had to sacrifice something in both volumetric efficiency and length of life, but the cost of equipment and space required have been greatly reduced.

The other great economic reason for the opening of the field to the electric driven machine has been the almost total swing to the production of raw water ice. With the ushering in of the manufactured ice business in the early eighties, there came a general demand for an ice as clear or clearer, than the natural river or lake ice. The answer was distilled water ice. White ice is caused by the presence of air, and the boiling or distilling of the water was adopted as the almost universal remedy.

The idea of furnishing distilled water ice was a boon to the ice business. To the public mind, distilled water meant absolute purity. That much of this purity was questionable, anyone who has been associated with the growth of the ice business must subscribe. To the writer who has had unusual opportunity to watch the development of the ice business, there is no question that the raw water supply in the average American city is far safer than the distilled water of the old type of ice plant.

Discovery and subsequent almost universal adoption of methods of producing clear ice by circulating compressed air through the freezing water eliminated the distilled water plant from the field. Without the need of condensed exhaust steam for the distilled water, there was no real need for boilers in the ice plant as all other features of the business could be handled electrically. This development was, then, the greatest single factor in

*Professor of mechanical engineering, University of Tennessee.

the introduction of the electric driven ammonia compressor.

Electric Driven Ammonia Compressor

Advantages offered by electric driven over steam driven ammonia compressors are:

1. Cost less to equip plant per ton of ice capacity.
2. Occupy less space.
3. Can be operated with less plant labor.
4. Operating expense is nearly proportional to output.
5. Greater flexibility in operation.

The disadvantages are:

1. Operates at lower volumetric efficiency.
2. High speed involves more repair expense and shorter life.

Cost of Equipping Plant

Cost per ton of ice capacity is greater for small plants than for large plants. This holds true either for an electric driven or steam driven plant. The curves of Fig. 1 give the approximate cost per ton, at present prices, for plants of from 8 to 400 t. daily ice making capacity.

Space requirements of a slow speed engine drive have always been a matter of much concern where space was at a premium. Vertical machines of the slow speed type have always required so much overhead room to permit the pulling of the piston while the horizontal machines have been equally disadvantageous in requiring such a large floor area. The installations of electric machines replacing these steam units often occupy only 20 to 25 per cent of the space occupied by units of similar capacity.

Labor saved in the electric driven plant is largely that of the boiler room. This is on the assumption that, in the cost of coal, delivery charges to the boiler room are included.

The item of maintaining the operating expense nearly proportional to the output is of great importance to the ice industry. Theoretically, the winter season of the year should make possible the production of ice at a low figure,—in fact, much lower than in summer. The available condensing water is very cold, thus giving low head pressures on the compressor. The can water is usually near freezing when the cans are filled, and melting losses are negligible. Yet in spite of these favorable factors, the cost per ton of producing ice with the steam plant soars upward in winter on account of the low efficiencies of the underloaded boiler, engine, and boiler room force.

An example of flexibility is best explained by a novel plant operating schedule of one southern owner of several plants in one city. Of his four plants, only one is electric driven, the others all having been installed some years past. The electric driven plant has become his stand-by plant due to the fact that it can be readily started or stopped without the cost or trouble of carrying banked fires, and without shifting a boiler and engine room force from one plant to another.

With electric drive, while the operating efficiencies do run somewhat lower on underloaded motors, the kilowatt hour input is more nearly proportional to the ice tonnage output, and the loss due to reduced electrical efficiency is more than made up by the reduced power requirements made possible by the colder water temperatures of winter time.

The Ice Plant Load and the Power Rate

Few industrial loads are as desirable at central stations as the motor driven ice plant. Figure 2 gives a characteristic industrial power and lighting load by seasons of a typical central station. Peak loads exist almost universally in the mid-winter months when heavy lighting and power demands occur simultaneously. With the coming of summer the lighting loads fall heavily, and the industrial loads are usually effected downward by vacation influences and similar effects.

Ice plant load superimposed upon such a curve scarcely adds anything to the winter peak, while the summer load of the typical ice plant fills in the depressions of the central station load curve.

In addition to this, the monthly load factor of the ice plant is exceptionally good. In the period of summer demand load factors of 70 per cent are common,

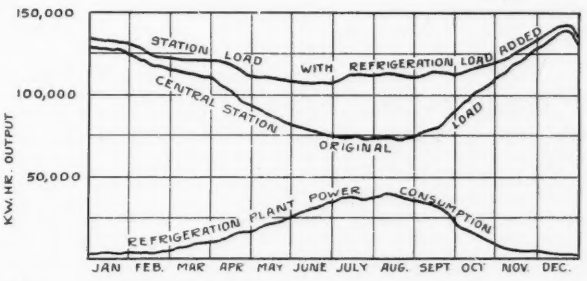

150,000
100,000
50,000
KW. HR. OUTPUT
STATION LOAD WITH REFRIGERATION LOAD ADDED
CENTRAL STATION ORIGINAL LOAD
REFRIGERATION PLANT POWER CONSUMPTION
JAN FEB. MAR APR MAY JUNE JULY AUG. SEPT OCT NOV. DEC.

FIG. 2. CURVES SHOWING DESIRABILITY OF ICE PLANT LOAD TO GIVE BETTER CENTRAL STATION LOAD

Ice plant demand is high when the industrial and lighting load is low and vice versa.

and for any one month a load factor of 40 to 50 per cent can readily be maintained.

A further factor that makes the ammonia compressor a desirable load for the central station is that it adapts itself so readily to synchronous motor drive. In nearly every locality, a synchronous motor reactive load is welcomed by the central station to balance up the inductive loads on the system.

Dump Power Rates

While dump power was a term originally applied only to the surplus available water power that could not be retained in storage, but which would be lost over the spillway if not used in a given time, it is now equally applied to the unused part of the central station's capacity, whether steam or water power.

In agreements to remain off the power line when the daily peak load is being supplied by the central power station to its customers, owners of ice plants often can secure a very advantageous rate for winter filling of storage houses. In some states such an agreement must be approved by the rate commission, but usually the rate commission will extend its approval on request of the power company.

From previous discussions, the factors governing the power required per ton of ice produced have been explained. For standard conditions, a theoretical power

requirement of 0.97 hp. per ton of refrigeration per 24 hr. is required. When allowance is made for volumetric efficiency and machine losses, this is increased to nearly 1.4 hp. per ton.

To this power requirement must be added the power necessary to drive the auxiliaries such as circulation pumps, and compressors, and similar pieces of equipment.

The high average records of the electric driven machines in actual service today over periods of one month when using cold condensing water are 36 to 38 kw-hr. per ton of ice produced. With warm condensing water this power consumption will increase to from 42 to 52 kw-hr. per ton of ice.

At 36 kw-hr. per ton of ice produced in 24 hr., the hourly rate per ton is 1.5 kw. per ton of ice, or the equivalent of about 2 hp. When it is considered that a ton of ice is equivalent to 1.3 tons of refrigeration on the basis of 52 deg. F. can water, and 16 deg. F. ice, and that the above 2 hp. includes the driving of necessary auxiliary units, it is good evidence that the ice making industry is approaching closely to its theoretical possibilities.

Where the Steam Driven Plant Can Compete

Steam driven compressors can compete where the distributors of industrial current fail to realize the desirability of the ice plant load and demand an excessive rate. Further, if refuse fuel is available for making steam, or if the ammonia compressor is only one of several units operated from a central boiler plant of sufficient size to insure efficient operation, then there is little possibility of the electric machine competing with the steam drive, unless an exceptionally low current rate is available.

For very low temperature work, the steam absorption unit usually cannot be successfully replaced by the electric driven compressor since the cost of operating the compressor increases too rapidly with the lowering of suction pressures.

How to Keep the Monthly Electrical Demand Load Factor High

Some engineers question the possibility of keeping the load factor high for each month when such load factor is based on the maximum demand. They argue that when the machine is running it will require virtually full load kilowatt input, and to keep the load factor high it would be necessary to operate more than 50 per cent of the time. Often this is undesirable in the winter time when the demand is light.

Such a problem should be met in the design of the plant. Instead of installing large compressors it is often desirable to install three or four small compressors, each one individually driven. When a small monthly output is required, one machine may carry the load at a high load factor. In the spring and fall, when the demand is still at a low point, it may be necessary to run two of the machines. But the load factor would still remain above 50 per cent, as is evidenced by the fact that one machine could not produce the output.

When heavy demand of summer arrives, all the machines can be put into operation and still give a demand low enough as compared with the total power consumption to keep the load factor above 50 per cent.

Effect of Abolishing the Steam Plant on the Refrigeration Engineer

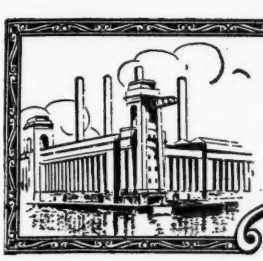
Refrigeration engineers are often prone to give up the steam plant because they believe it will reduce their own work to a mere ice pulling job. No doubt some firemen and other engine room assistants will lose out in the shift from steam to electric drive. But the release of the refrigeration engineer from the responsibilities of supervision of the boiler room and engine room, and the incident problems of power plant maintenance and repairs should give him more time to develop his refrigeration plant operating ability. The boiler room has always been looked upon by the majority of ice plant owners as a non-productive expense item, and all associated with this end of the enterprise have usually received a minimum of recognition. With the passing of the boiler room, there is presented to most engineers the opportunity of relating themselves more directly with the financial and business end of the ice-making or storage business. If they will adapt themselves readily and enthusiastically to this new field, their services should be more quickly and substantially recognized by the management. No doubt our ice plants will be maintained in much better condition with the burden of the boiler room removed from the engineer's routine.

Oregon Possesses Great Water Power Resources

Potential water-power resources of Oregon amount to 3,665,000 hp., as estimated from the stream flow available 90 per cent of the time, or 5,890,000 hp., as estimated from the flow for 50 per cent of the time, if storage is provided in feasible reservoir sites, according to a statement made public by the Department of the Interior based on field work and studies of the Geological Survey. River surveys have been made and maps published by the Geological Survey covering 1674 mi. of rivers in Oregon. The river surveys included a number of reservoir sites, and in addition 47 dam sites were surveyed on a large scale.

Some idea of what nearly 6,000,000 hp. of potential water power in the rivers of Oregon may mean to the future of the state can be gained from the fact that so far only about 3 per cent of these water-power resources have been utilized and that, with complete development, the installed capacity of water wheels might amount to 8 million horsepower or more. The latter figure may be compared with the installed capacity of water wheels in plants of 100 hp. or more in the whole United States, which, at the end of 1926, amounted to 11,721,000 hp.

Many of the maps of the rivers in Oregon have been published by the Geological Survey in its regular water-supply papers. Others are published as river-survey maps, which can be purchased for 10 cents a sheet from the Geological Survey, Washington, D. C. The sections of rivers covered by these surveys made before 1927 are listed in Water-Supply Paper 558, which can be purchased for 25 cents from the Superintendent of Documents.



LETTERS DIRECT FROM THE PLANT

Inverting Valve Handle Avoids Accidents

IN CONNECTION with the recent installation of two 15,000-kw. hydroelectric generators, the specifications called for protection in case of fire. This consisted of a water line inside of stator frame and having a series of discharge points. A 1½-in. line served each unit and was provided with a cutoff valve just outside of the generator frame.

Now, the problem was what to do with the valve handle to avoid the possibility of turning the valve on as a result of excitement on the part of some operator.

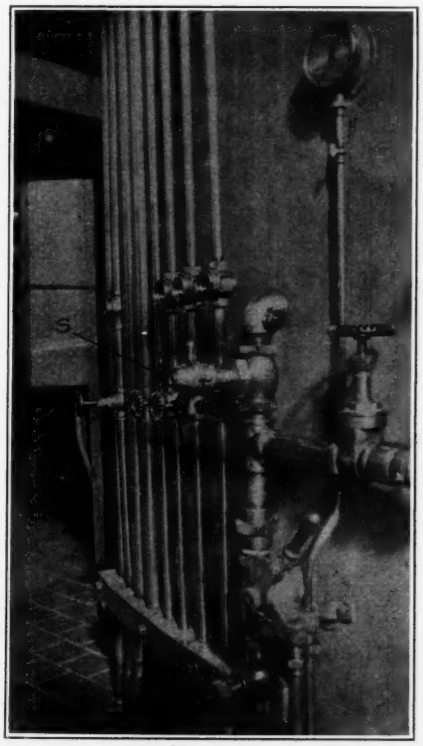


FIG. 1. VALVE HANDLE IN INOPERATIVE POSITION

The usual box arrangement with glass front and a hammer dangling from a chain did not appeal to us as harmonizing with the "brand-newness" of our station and its equipment.

To the station mechanic belongs the credit of neatly as well as ingeniously solving the problem. The details are better explained in the two illustrations shown. The important point is that the newly designed valve handle must be backed off and turned end for end before it can be applied to the valve stem. This provides sufficient time in which an operator must either know what he is doing or his nerves go to pieces.

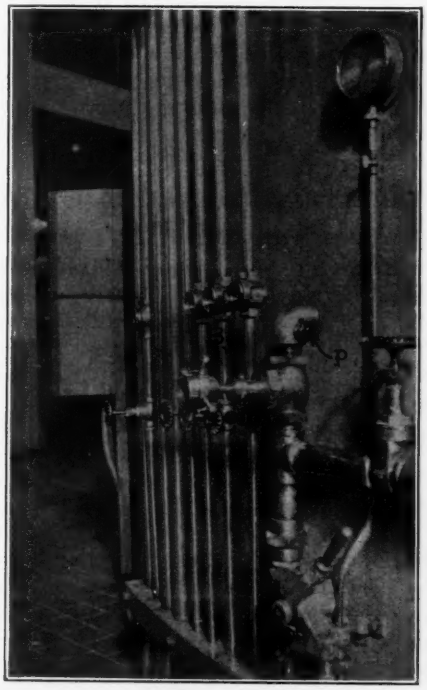


FIG. 2. VALVE HANDLE WITH ITS SQUARE SOCKET HOLE ENGAGED WITH VALVE STEM

Figure 1 shows the valve handle in normal position. Note the square socket hole at S which fits on the valve stem when it is reversed. The socket and radial spokes are of steel, while the main part is of brass. The original valve bonnet was turned down in a lathe and a sleeve shrunk on and threaded to receive the brass handle as shown at B in Fig. 2. A petcock to detect leakage was installed at P. In Fig. 2 the valve handle is shown reversed and fitted to valve stem ready for opening the valve.

Columbus, Georgia. J. JACOBS.

Count Gasoline Engine Explosions

BY COUNTING the explosions of a gasoline engine and doing a little simple figuring, it is possible to determine the efficiency of any gasoline engine of the hit and miss governing type with surprising accuracy.

Subtract the number of explosions per minute made by the engine when it is pulling no load at all, from the

number of explosions per minute when pulling full load. Then divide the remainder by the number of explosions per minute when pulling full load, and the quotient is the mechanical efficiency.

For a gasoline engine that explodes 95 times per minute when pulling full load, and 24 times per minute when pulling no load at all, the difference is 71. In other words, 71 of the explosions are utilized when pulling full load, whereas 24 of them are lost in overcoming the internal friction in the engine. 71 ÷ 95 = 75 per cent—a rather low efficiency.

Reduction of explosions at no load simultaneously increases the power of the engine without consuming an ounce more of gasoline. If the number could be cut down from 24 to 10, we would have 14 useful explosions to add to the 71, which gives 85. Or, dividing 14 by 71, we find that the power of the engine has been increased 19.7 per cent. It is doubtful if such an increase could be added to any engine, unless the engine were in a very poor state before the improvement began.

Newark, N. J. W. F. SCHAPHORST.

Storage Tanks Moved in Unprecedented Way

IN BUILDING its No. 3 plant at Long Beach, the Southern California Edison Co. found it necessary to move two steel fuel oil storage tanks, each having a capacity of 300,000 gal.

In the past a number of schemes have been tried, but really no good method has ever heretofore been used, for in the most cases the tank would leak badly, making it necessary almost completely to repair the tank. The engineers of Stone & Webster, Inc., conceived the idea of building dykes about 4 ft. high and 100 ft. apart throughout the entire distance from the old settings to the new location of the tanks, a distance of about 1000 ft. After draining the tanks and disconnecting the pipe lines, they filled this space between the dykes with 2 ft. of water, a height necessary to float the tanks. They were then easily floated in this artificial lake to their new location.

Those who have never moved a fuel oil tank will hardly appreciate this wonderful achievement, but the engineer who has, will appreciate this more when I say that after the tanks were placed on their new foundations by draining the water from the pond, it was found that the tanks suffered absolutely no strain and did not leak.

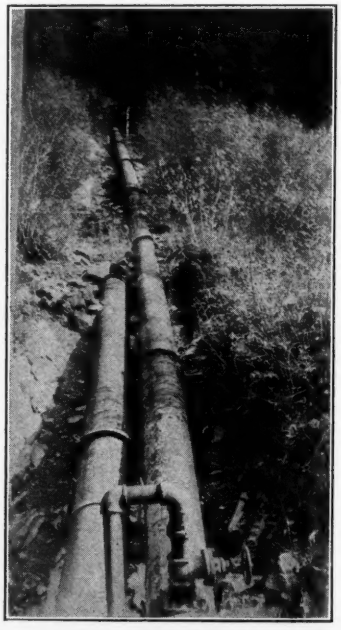
It has been the custom in moving fuel oil tanks to take them apart in sections and rebuild the tanks at their new location. This novel engineering plan will save time and money, and result in a better job. Experience has shown that after rebuilding a tank, it was necessary to recalk it almost all over as it usually leaked at nearly every joint.

Los Angeles, Calif. W. D. CAMPBELL.

Safety Valves Prevent Collapse of Pipe

ENGINEERS are at a loss to explain the collapse of a 14-in. pipe which occurred recently at the plant of a large mining company in the northwest. The pipe is spiral riveted 14 in. in diameter and carries water from a mountain flume to a Pelton water wheel which drives a 2200-v. generator. The pipe consists of 22 sections each 20 ft. in length and has a drop of 230 ft. The pressure at the Pelton wheel, when running at full load, is approximately 100 lb. per sq. in.

About the middle of the forenoon on the day in question, when everything was running smoothly, a loud report was heard and the attendant found, upon investigation, that the second, third and fourth 20-ft. sections had collapsed. About 3 min. later another loud report was heard and the seventh, eighth and ninth sections also were found to have been flattened. The second collapse tore one end of section nine from the flange by which they are joined, releasing the water and preventing further damage. Had the upper end of the pipe been blocked in some way, the vacuum formed



SPIRAL RIVETED WATER PIPE COLLAPSES UNDER PECULIAR CIRCUMSTANCES

would undoubtedly have been sufficient to cause the pipe to collapse, but, in view of the fact that the flow of water was not stopped, no satisfactory explanation has been arrived at. After the damaged sections were replaced the whole line was fitted with safety valves opening inward, making a repetition of the accident unlikely.

Wallace, Idaho. L. R. RAYMOND.

Deterioration of Lead Sheathed Cables

LEAD SHEATHED cables, when buried in the ground, are often attacked by corrosion at a rate largely dependent upon the nature of the soil and upon the composition and previous history of the lead sheath. Pure lead is fairly resistant to corrosion, but its resistance is greatly affected by the presence of any impurities in the lead itself. These impurities are not dissolved in the metal itself, but exist in the solid state and are lodged between the grains of the lead.

In the presence of an electrolyte, the raw materials for a small primary cell are present; the pure lead becomes the cathode and the impurity the anode and a small local current circulates between them, whose magnitude is largely dependent upon the composition of the impurity. An alloy of lead and tin is more resistant than pure lead; tin readily alloys with lead and forms a solid solution; tin itself strongly resists corrosion and on this account increases the resistance of the lead. The percentage of tin is usually quite small. A small percentage of antimony is often added, causing the corrosive resisting properties of this alloy to be less than that of pure lead. Antimony is slow to enter into solution with lead and it is largely squeezed to the edges of the lead crystals as a eutectic. It is widely separated from lead in the e.m.f. series: Tin and lead conform very closely in this respect.

An ideal alloy would be one with a high percentage of lead, a smaller percentage of tin and a small amount of antimony, for example 6 per cent lead, 3 per cent tin and 1 per cent antimony. Cables laid in corrosive soils will surely be attacked if they are not protected. Soils containing cinders, chemical refuse, those in the vicinity of breweries or tanneries, or those under oak trees, should be avoided. Filled-in ground is always liable to be corrosive and there is also a risk of subsidence. Good drainage is essential; corrosion troubles are increased with bad drainage. Ordinary Portland cement is highly corrosive to lead and patent cements are often worse. Lead cables should never come in contact with these. Asphalt coverings over the cables give effective protection provided they are continuous, but where soil is known to be corrosive, the safest plan is to lay the cables solid.

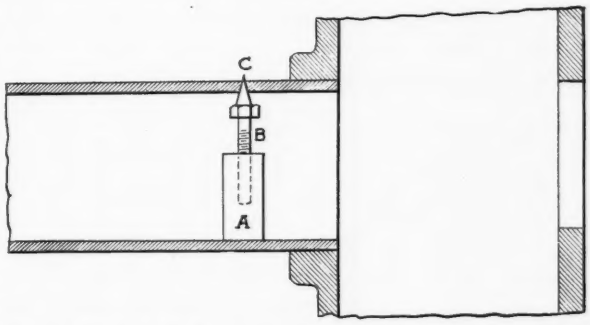
Electrolytic corrosion is also likely to arise through leakage currents which flow along the lead sheaths where the resistance of the soil is high, but if the resistance of the soil becomes lower, say through an increasing moisture content, part of the current may leave the cable and go into the soil, returning to the cable as the resistance of the soil increases. This leads to electrolytic corrosion and points to the necessity of keeping the leakage currents at a minimum and grounding the sheath at convenient places to localize the points where these currents ground.

Crystallization and weakening may arise through tensile strains or vibration. Tensile strains can be avoided by supporting the cables well and taking precautions against subsidence. Vibration, such as found on bridges or in buildings where machinery is in operation, is often troublesome. In these cases, the cables should either be laid on some soft material to damp out the vibrations or hung from a carrier rope by flexible supports. Care should be taken that there is no possibility of the cable becoming chafed through rubbing on any object, or of resonant vibration. For this purpose the supports should not be equally spaced. With high tension lead covered cables a frequent source of failure is that due to careless bending. The fewer the bends and the more gradual they are made the better; when a sharp bend is made in a heavy cable the outer side is considerably stretched and the inner side crimped, this naturally strains the sheath, it is also liable to create voids and spaces in the insulation, or to cause the core to become decentered which in time causes electrical failure.

Brentford, England. W. E. WARNER.

Screwed Pin Stops Leak

CLOSE TO the header of a water tube boiler, a very small hole appeared on the top of one of the tubes. The sketch shows how the hole was temporarily closed until opportunity for retubing occurred. In this case such opportunity did not come for several weeks.



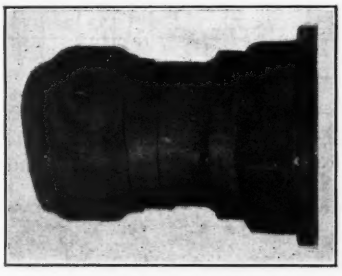
TAPERED PIN IS FORCED INTO HOLE BY UNSCREWING A BOLT

A piece of square iron, A, was drilled and tapped for a ½-in. bolt, B. A long, tapered steel pin, C, was entered into the hole as shown, then, holding the tapered pin, A, stationary and unscrewing B, the bolt head forced the pin into the hole and it was effectively sealed.

Hollyburn, B. C., Canada. JAMES E. NOBLE.

Excellent Thread and Fit Protector

IT IS a common practice to tie thread or other fit ends securely with burlap and cord when they are on a part which is likely to be hit or "jimmed" during storage,



INNER TUBES FURNISH PROTECTION TO ENDS OF FINISHED MACHINE PARTS

shipment or erection. I got a number of old inner tubes of various sizes from a garage and cut them off into short lengths. Working them doubled on the part to be protected is even better protection against "jimming" than almost any kind of a cloth protection. The rubber will much better protect a part from a severe blow from a sharp instrument than any other form of light covering. The pieces of rubber are easy to procure and to cut, and they sure stick on the job while they are there.

Missouri Valley, Iowa. FRANK BENTLEY.

QUESTIONS AND ANSWERS

Overloading Zeolite Softener Impairs Efficiency

WHAT EFFECT has the amount of work demanded of a zeolite water softener upon its efficiency of action; that

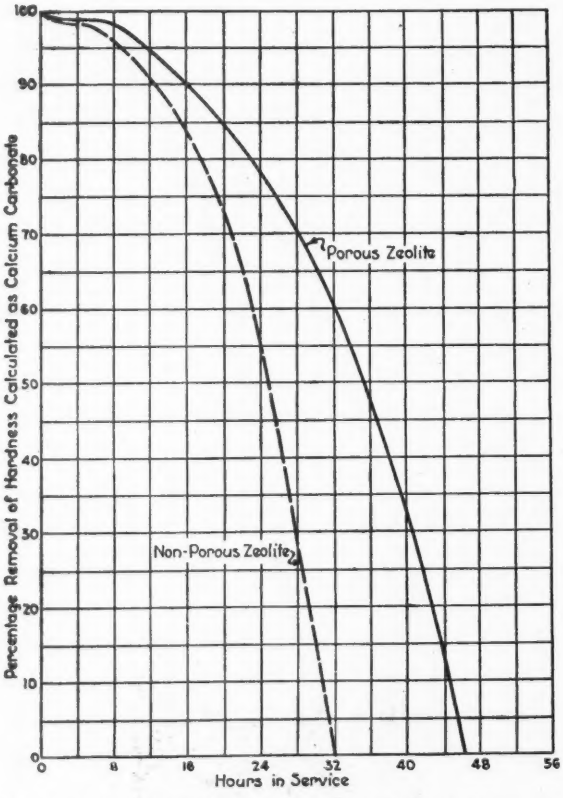


CHART SHOWING HOW MUCH THE EFFICIENCY OF ZEOLITE WATER SOFTENING MATERIALS IS REDUCED WHEN OVERLOADED

is, what is the limit to which it is wise to push such a softener?

Newark, N. J. E. C.

A. Overloading a zeolite water softener gradually lowers its efficiency but the softening material will continue to soften the water partially until the sodium content has been largely exhausted. The curves plotted in the diagram illustrated were made from results obtained by passing water through two zeolite minerals, one porous and the other non-porous. The results show that both minerals functioned satisfactorily for 8 hr., the rated capacity of the softeners. From that time on there was a reduction in the percentage of removal of calcium and magnesium. It will be noted that the non-porous zeolite shows a lower efficiency than the porous one and was completely exhausted 14.5 hours earlier. This is because of the greater depth of the mineral bed since the same weight was used in each instance and the porous substance, being lighter, is more bulky.

Efficiency of such softeners will be influenced markedly by the condition of the beds, the care in regenerating the material and the rate of filtration through the bed. If the bed of zeolite is not backwashed properly, there is danger of disturbing the under-draining system and driving the gravel up into the zeolite. Most softeners are designed to prevent backwashing at excessively high rates. Operators, at times, exceed the designed rate of backwash and therefore invariably experience trouble. The rate of flow through the apparatus varies with different zeolites, since the depth of the mineral bed and the kind of zeolite influence the permissible velocity at which such softeners will function satisfactorily.

Steam Heating and Steam Flow

PLEASE ASSIST me in the following questions:

1. Is it possible for me to get the approximate amount of coal used to keep a boiler feed pump running by figuring from the volume of steam used per stroke?

2. Which is the more economical to use on a steam heating system, two coils with 30 lb. pressure, or four coils with 5 lb. pressure? All coils the same. About what per cent would be the gain either way?

3. How can I get the weight of steam per cubic foot at varying pressures?

4. When steam is superheated does the temperature of the steam rise above that of saturated steam for the given pressure? Does it have to be superheated after it leaves contact with the surface of the water in the boiler to obtain this?

5. How many B.t.u. are required to evaporate 1 lb. of water into steam at varying pressures? Please give formula.

6. How would you find the number of cubic feet of steam or volume in 1 lb. at varying pressures?

7. How do you find the weight of steam flowing into the atmosphere at a given time when the pressure exceeds 25 lb.? When below? T. B. B.

A. You may ascertain the approximate amount of coal needed to operate your boiler feed pump if you know the steam rate per pound of coal of your boilers. The steam consumption of your feed pump may be obtained by condensing the steam exhausted in a tub of water. The difference in weight for a given time represents the steam consumption for that period.

2. After radiating coils have been heated to steam temperature, increasing the steam pressure does not add

much to the heat radiating effect of the coils. The temperature of dry and saturated steam at 5 lb. gage pressure is 228 deg. F., while that at 30 lb. gage is 274.5 deg. But increasing radiation surface greatly increases the amount of heat radiated if the coils contain a sufficient quantity of steam. This will be shown by referring to the table herewith.

3. The weight of steam per cubic foot at any given pressure may be obtained from steam tables which always show the density in pounds per cubic foot for all pressures listed. Recent steam tables list pressures up to 600 lb. absolute pressure.

4. The temperature of steam above that corresponding to dry and saturation at a given pressure represents the degrees of superheat of that steam. Steam cannot be superheated while it is in contact with water because the heat added with the intention of superheating would then be absorbed in converting water into steam.

5. The amount of heat required to evaporate 1 lb. of water from 212 deg. F. to steam at 212 deg. F. is

HEAT EMISSION IN B.T.U. PER LINEAL FOOT OF COIL, NOT PIPE, PER HOUR OF DIRECT PIPE COIL RADIATION FOR STEAM WITH WALL COILS PLACED VERTICALLY; PIPES HORIZONTALLY. STEAM TEMPERATURE AT 240 DEG. F. PRESSURE 10 LB. PER SQ. IN. ROOM TEMPERATURE AT 60 DEG. F.

Size of Coil	1 in.	1-1/4 in.	1-1/2 in.
Single Row	175	215	245
Two	335	413	462
Four	584	724	816
Six	752	930	1050
Eight	864	1064	1200
Ten	970	1200	1350
Twelve	1075	1330	1500

listed for different pressures in steam tables. This heat which is given in B.t.u. is called the latent heat of evaporation, being determined by experiment and not by formula.

6. The number of cubic feet of steam in 1 lb. at different pressures is listed in steam tables under the head, specific volume in cubic feet per pound.

7. The flow of steam of a greater pressure into an atmosphere of a lesser pressure through an orifice with well-rounded approach increases as the difference of pressure increases until the external pressure, P_E, becomes only 55 per cent of the absolute pressure, P_I, in the chamber before the orifice. The flow of steam is neither increased nor diminished by the fall of the external pressure below 0.55 P_I even though P_E becomes a perfect vacuum. The pressure at the throat, P_T, remains 0.55 P_I with low values of P_E. If the external pressure is equal to or less than 0.55 P_I, the maximum discharge of an orifice or nozzle with short, well-rounded approach is given by the equation:

$$W = 0.3155\ A\ \sqrt{P_I \div V_I}$$

where

W = steam flowing in lb. per sec.

A = area of throat or narrowest section in sq. in.

V_I = specific volume of steam at pressure P_I in cu. ft.

P_I = absolute pressure before nozzle in lb. per sq. in.

If the external pressure, P_E, is greater than 0.55 P_I, the discharge is found from the formula:

$$W = 223.7\ A\ \sqrt{K\ (H_1 - H_2)}$$

where

K = nozzle efficiency = unity when throat is very short = 0.88 to 0.94 in orifices of Rateau turbines.

$H_1 - H_2$ = heat available in B.t.u. from adiabatic expansion from initial conditions to final pressure at discharge.

Elevation Affects Barometric Reading

MAY I ASK what the vacuum reading would be at 5000 ft. elevation above sea level if it is 30 in. at sea level? Why is it less than at sea level? A. L. J.

A. Atmospheric pressures and barometric readings corresponding to various altitudes from sea level to 10,000 ft. above sea level are given in table below:

Altitude Feet	Atmospheric Pressure Lb. per sq. in.	Barometric Reading Inches of Mercury
0	14.7	30.0
500	14.4	29.4
1000	14.2	28.8
1500	13.9	28.3
2000	13.6	27.7
2500	13.4	27.2
3000	13.1	26.7
3500	12.9	26.2
4000	12.6	25.7
4500	12.4	25.2
5000	12.1	24.7
5500	11.9	24.3
6000	11.7	23.8
6500	11.5	23.4
7000	11.2	22.9
7500	11.0	22.5
8000	10.8	22.1
9000	10.4	21.2
10,000	10.0	20.4

Following the condition prevailing with reference to all attracting bodies, the farther an attracted body is away from the center of the earth, the less the force of attraction.

Location of Safety Valve and Steam Outlet

YOUR ANSWERS to the following will be appreciated by the writer:

1. Why is the safety valve placed in back of the center line of a boiler?

2. At which end of a boiler should the main steam outlet be placed? W. J. S.

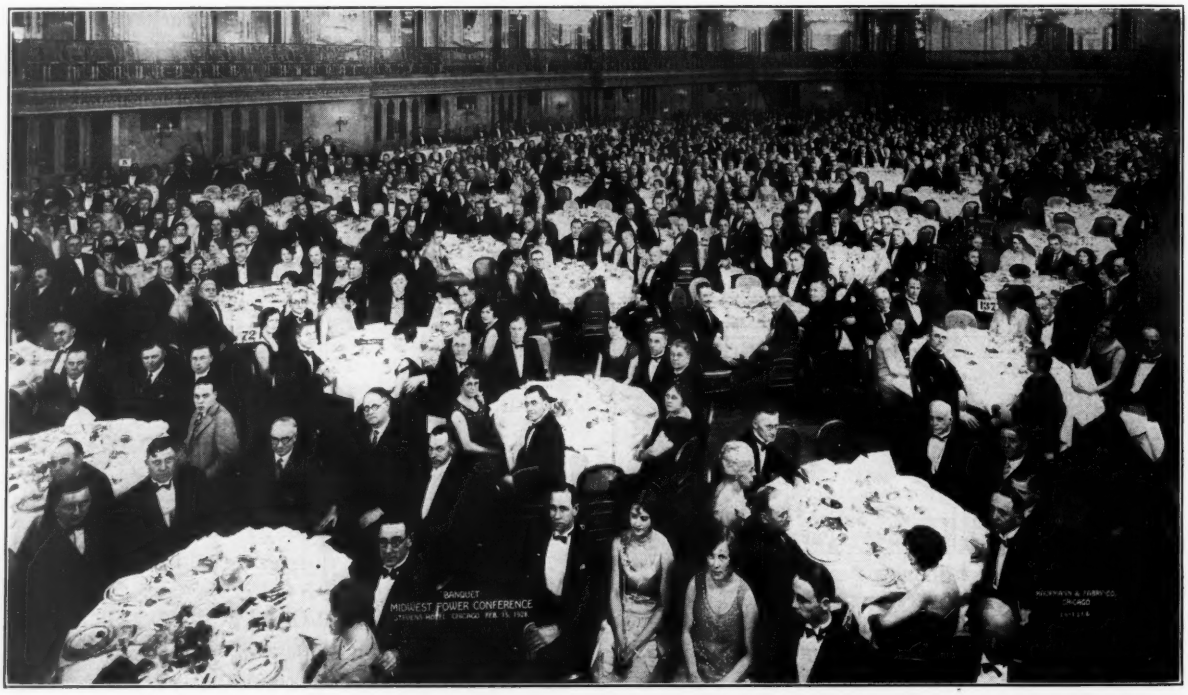
A. No definite requirement exists for the location of the safety valve on a boiler except that it should be away from the steam opening so that there will be no surging effect on the outlet when the safety valve blows. In three-course h.r.t. boilers the steam outlet is usually placed in the front course, the safety valve in the back course, and the manhole back of the center in the middle course.

2. The main steam outlet is placed where it is most convenient; the essential condition is that the steam be drawn from the high and dry point in the steam drum.

Varied Program Feature of Power Conference

THIRD MIDWEST POWER CONFERENCE, FROM FEBRUARY 14 TO 17, AT HOTEL STEVENS, CHICAGO, DEVELOPED INTO DISCUSSIONS OF GENERAL INTEREST

FROM ALL sections of the country, particularly the middle west, 900 engineers and others interested in the generation and use of power as well as flood control and river developments, met in the new Hotel Stevens during the days of February 14 to 17 to attend the Third Midwest Power Conference. The entire program was varied, dealing with the sociological aspect of power, relation of power development, flood control and other river problems, the economics of power stations and details of plant equipment.



GUESTS AT BANQUET OF MIDWEST POWER CONFERENCE

President Glenn Frank of the University of Wisconsin, was the principal speaker of the opening session held on Tuesday morning. His paper entitled "Power, the Background of Today's Civilization," dealt with a comparison of what he termed "machine civilization" with that of former generations. Machine Civilization, he divided into two classes which he termed "steam power and electric power."

Western civilization will have a good future in Dr. Frank's opinion, if electricity is developed to take power to the workers in comparatively small communities instead of forcing the workers to "go to power" centralized in great cities, with cramped living conditions. Steam power did force the workers to go to the cities, he said. He hoped that great electric transmission lines will "decentralize" industry and thus make man's social lot better.

"If the power resources of the nation during the next 25 yr. become pawns in a game of financial manipulation, we shall miss many if not most of the rich social benefits that power can bring to our civilization. And we shall find ourselves in the midst of a social revolt against the perversion of this great social asset to purely financial ends.

"The generation, sale and use of electric power represent a factor that, wisely administered, can remake our machine civilization, redeeming it from the sins that have shamed it in the past. But we shall not achieve this wise administration of this new power unless the voice of the engineer and the social statesman outweighs the voice of the financier in its development and control."

Major Rufus Putnam, as President of the Midwest Power Conference, gave the keynote of the Conference by picturing Chicago as the power capitol of the Great Lakes Region with a mighty present and a far greater future before it.

W. A. Durgin, Director of Public Relations of the Commonwealth Edison Co., Chicago, gave an extremely interesting illustrated lecture on "America's Part in the Romance of Power." In this he illustrated comparisons of conditions in America with those in other nations of our times and during past history.

Mrs. J. D. Sherman, President of the General Federation Women's Clubs, Washington, D. C., read a paper entitled "Drudgery Banished from the Home," in which she spoke of the survey of homes which the Federation has been working on for some time.

"How to Make the Burden Bearer Bear the Burden," was the topic chosen by Burke Corcoran, Secretary, Electric Association of Chicago. His paper advo-

cated the purchase of public utility securities by the people who are served by these utilities.

At the Wednesday morning session, the general subject was "The Relation of the Power Development to Flood Control and Other River Problems." During this session, General Edgar Jadwin, Washington, D. C., presented a paper on "General Flood Control Problems in the Mississippi Valley," Daniel W. Mead, Madison, Wisconsin, read a paper entitled "Problems of Storage for Flood Control and for Power Development," and Major G. E. Edgerton, Chief Engineer, Federal Power Commission, Washington, D. C., read his paper on "The Status of Hydro-Electric Development from the Viewpoint of the Federal Commission."

At the afternoon session on Wednesday other papers dealing with hydraulic problems were presented, the first being by Major L. H. Watkins on "The Tennessee River Survey"; another by E. A. Forward, Montreal, Can., on "Navigation and Power Development on the St. Lawrence River"; A. E. Allner, Baltimore, Md., contributed a paper on "The Combined Use of Water and Steam Power," and H. A. Hageman, Chief Hydraulic Engineer, Stone & Webster, Boston, Mass., presented his paper entitled "Progress and Trend in Hydraulic Power Developments."

Wednesday evening, the annual banquet and dance was held in the ballroom of the hotel at which 1100 were in attendance. The speaker of the evening was Rufus C. Dawes, who chose for his topic "International Finance."

Thursday morning, the session had to do with Economics of Power Stations, the papers presented being "Capitol Costs with Relation to Economy of Central Stations," by Alex Dow, President of The Detroit Edison Co., "High Pressure Operation," by Geo. A. Orrok, Consulting Engineer, New York City, and "Trend and Development in Steam Generation," by Thos. E. Murray of New York City, in whose absence was read by John H. Lawrence.

At a luncheon symposium, H. B. Gear's paper, read by W. L. Abbott, told of "Power Transmission by High Voltage Cables"; "Overhead Transmissions" was the subject chosen by H. W. Eales of H. M. Byllesby Co.; A. C. Montieth of Westinghouse Elect. & Mfg. Co. told of "Developments in Apparatus for Power Transmission Systems" and Wallace S. Clark, General Electric Co., presented a paper on "Some Causes of Failures in Impregnated Paper Insulated Lead Sheathed Cables."

Friday morning the session was given over to Economics of Power Stations, Fuel, Combustion, etc., the papers presented being "Combustion Control in Industrial Plants," by T. A. Peebles, Hagan Corp., Pittsburgh, Pa., "Boiler Room Organization Combustion Control," J. F. Shadgen, Smoot Engineering Co., New York, "Effect of Steam Reheating, Stage Feed Water Heating and Boiler Reheating on Steam Turbine Practice and Development," by Edward Brown, Allis-Chalmers Co., Milwaukee, Wis., and "Embrittlement of Boiler Plate," by Dr. S. W. Parr and F. C. Straub, University of Illinois.

Abstracts of a number of papers are printed on the following pages and others will be published in subsequent issues.

The Power Situation in the Heart of the Middle West

By Major Rufus W. Putnam, President, Third Midwest Power Conference

This is the third of a series of annual conferences at which are brought before power engineers and executives as well as the public at large well considered presentations of various aspects of that ever changing romance of the generation, distribution and use of one of Nature's most marvelous gifts to humanity: electricity.

The keynote of this Third Midwest Power Conference has been well expressed by your Executive Committee in these words:

"To cover the broader, national, regional and economic phases of the power situation, and to present broader problems in such a way as to appeal more directly to the operating and technical interests, as well as drive home to the great body of consumers the epic story of power so that the people in general may have a better appreciation of its service."

Before discussing the manner in which this keynote is to be expressed at this Conference, it might be well to review briefly a few of the factors which make the subject of power of so much importance to the Middle West.

The Great Lakes region, comprising chiefly the States of Wisconsin, Illinois, Indiana and Michigan, while not located in the geographic center of the great Middle West, is generally looked upon as the economic center of this still comparatively undeveloped inland empire, which stretches from the Appalachians to the Rocky Mountains. In some respects this region is the economic center of the entire United States as well. It therefore would be logical to expect these four States to be the site of a great commercial and industrial development; and this is the case, though the potentialities of the favorable economic situation have not been as fully realized as in the Eastern States, where the necessary element of time has brought about a larger and more diversified industrial growth.

It is also noteworthy that the Great Lakes region has not only kept pace with the growth of the electrical industry, but has always been a leader in fostering new developments. For instance, there has been a great deal of open-mindedness about the question of interconnection, with the result, as a glance at the transmission line map of this region will show, that the practice of tying parts of a distribution system together so as to form a well-balanced net and permit the ready dispatch of power to any part thereof, and of joining the separate systems for the same purpose, is perhaps more universally followed here than in any other section of the country.

In the matter of developing efficient central station equipment, the Great Lakes region is well in the foreground. It is partly the great advance made in central station size and efficiency which has hastened the extension of interconnection and brought it to its present satisfactory state. On the other hand, widespread use of interconnection has made it practicable to centralize power production, particularly in the vicinity of large

cities like Detroit and Chicago, so that large generating units are not only practical, but desirable. The two developments have come forward in parallel and cannot be disassociated.

As an example of this tendency to undertake large-scale operations which go so far toward reducing production costs, attention is directed to the project for the State Line Generating Co., whose first plant is now under construction on the shore of Lake Michigan on the Indiana side of the Illinois-Indiana State line. This project contemplates the manufacture and sale of power on a wholesale basis to several Illinois and Indiana companies whose transmission lines have been brought to a common focus at that point. The present projected capacity of this plant is 1,000,000 kw.; its first unit is a monster affair which will produce over 200,000 kw.

The present condition of affairs as regards interconnection in the Great Lakes Region is well illustrated by a transmission line map of the area. Chicago, approximately at the geographic center of this region, will be found to be a tie-in point for most of the transmission line systems, and continuous electric connection to the remote portions of the region is thus available.

To the north, the lines extend through the farming and dairy sections of Wisconsin as far as the iron mines of the northern peninsula of Michigan. They cross the Mississippi River in their westward course at Dubuque, Davenport and Keokuk, and continue uninterrupted through the rich farming country of the State of Iowa. To the southwest, the transmission lines connect Chicago with St. Louis, a large center of commerce and industry, crossing the heart of the Central Illinois coal fields. To the south, the lines reach the limits of the Great Lakes region at Cairo, Ill., serving the Southern Illinois coal fields on the way. Interconnected systems link the Chicago district with most of Indiana, where, except for the industrial concentration in the northern part of the State, the development is largely agricultural, and extends in unbroken lines across the Ohio River into Kentucky, serving the coal fields of that State and tapping its water powers. To the east, connections from Chicago are not so direct; nevertheless, they reach the boundaries of the region in that direction by way of Lima and Toledo, Ohio; and from Toledo they proceed to Detroit and Eastern Michigan, thus serving the industrial districts near the west end of Lake Erie.

In addition to the major transmission systems, the Great Lakes region is served by fairly extensive distribution systems. Outside of local systems in cities and towns, in 1925 Illinois had approximately 7000 mi. of transmission and distribution lines, and Wisconsin 5800 mi.; Indiana had 5350 mi. and Michigan 4550 mi. Considering densities, Indiana had one mile of line for every 6.73 sq. mi. of territory; Illinois had one for every eight square miles; while the respective areas per mile of transmission line for Wisconsin and Michigan were 9.57 and 11.9 sq. mi. On a population basis, Illinois had 935 persons per mile of line, Michigan 900, Indiana 570 and Wisconsin 475. The populations per square mile (1925) were as follows: Illinois 123, Indiana 84, Michigan 70 and Wisconsin 50.

It is interesting to note the almost complete electrification of the iron and steel industry in this region, particularly as compared with the state of affairs in the manufacturing districts of the East. Whereas in 1923 about 51 per cent of this industry in the Ohio-Pennsylvania district was electrified, the degree of electrification in the Great Lakes region in 1924 was 86 per cent; and the percentages of power used that were supplied by public utilities were 30 and 44 respectively.

The power resources of this region are worthy of note, and should be taken into consideration in any review of the objective features of the public utility situation. The installed generating capacity of central stations and electric railways in the States of Wisconsin, Illinois, Indiana and Michigan is now about 4,000,000 kw., over 40 per cent of this being in Illinois. Of this slightly over 400,000 kw. are developed by water power, a ratio of about 11 per cent of the total. The great dependence of this region upon steam power is thus indicated, particularly when it is realized that of all the electricity generated in the United States about 33 per cent is developed by water. As regards the four states separately, about 4.2 per cent of the electricity produced by public utilities in Illinois is generated by water power, in Indiana 6.1 per cent, in Michigan 28 per cent, and in Wisconsin 48 per cent.

The utilization of water power in this area has progressed to a state where about 50 per cent of the total water power (estimated to be available for 50 per cent of the time) has been developed. Since the water power installations already made have been built where conditions have been most favorable, it is quite likely that future growth in the development of this class of power will be rather slow.

The Great Lakes region has very extensive coal fields within its own boundaries, though it is quite interesting to note that a considerable proportion of its fuel comes from without. Though the greater part of Southern Illinois and half of Southern Indiana are underlaid with coal deposits, Milwaukee and points north and west of it in Wisconsin receive large quantities of fuel by lake, coming from eastern coal fields by rail to the Lake Erie ports. The freight rate structure is responsible, of course, for this apparently uneconomical routing; but it is a fact that Milwaukee serves as a coal port for a larger hinterland in the central part of the state.

Taken as a whole, there is every reason to believe that the power situation in the Great Lakes region, as well as throughout the Middle West, may be viewed with as much optimism for the future as satisfaction over the accomplishments of the past. The pioneering spirit still prevails, and as long as it continues, much progress is yet to be looked for.

Problem for Flood Control and for Power Development

By Daniel W. Mead

Actual use of storage reservoirs will, I believe, give the clearest idea of the feasibility of the combined use of storage for flood control and for power purposes.

That reservoirs under favorable circumstances may be used successfully for both flood prevention and water powers is demonstrated by the regulation of the St. Mary's, Niagara and St. Lawrence Rivers by the Great Lakes System. While the regulation of these streams is

not perfect, it is sufficiently complete so that no serious floods occur except from occasional ice jams, and the flow is sufficiently constant to permit a large and profitable use of the waters for navigation and water power.

The flow of the St. Lawrence at the outlet of Lake Ontario averages about 255,000 cu. ft. per second, and the variation above and below that quantity seldom exceeds 30 per cent. While this is not perfect regulation, it approaches such condition sufficiently to prevent serious flood and to improve greatly the stream flow for water power purposes over what would obtain without regulation. The regulation of these rivers is the result of a storage area in the Great Lakes of about 95,600 sq. mi., or about one-third of the entire drainage area. While the maximum variation in the water level of the Great Lakes during a considerable term of years is about 4 ft., the annual variation is about 1 ft., and the annual storage is about 60,000,000 acre feet. Such regulation on the Mississippi River drainage area would be both physically and financially impossible.

PANORAMIC VIEW OF THE WISSOTA HYDRO-ELECTRIC DEVELOPMENT OF THE NORTHERN STATES POWER CO.

That similar complete regulation cannot be artificially produced on any but small streams, and then only under particularly favorable circumstances is almost self-evident. Any regulation attempted on the Mississippi drainage area must be so limited in extent that it must be practically confined to the particular purpose for which it is created, and can be of little service to other ends.

Here the author discussed in some detail the reservoir system of the upper Mississippi River drainage area, the reservoir system of the Wisconsin River, the Chippewa River reservoir system, also discussed irrigation reservoirs of the Mississippi drainage basin, the Miami Conservation District reservoirs and reservoirs for flood prevention, all of which led to the following conclusions:

1. That approximately complete control of a river system such as is provided by the Great Lakes is of definite advantage to both flood prevention and water power development but that such control is practically impossible by artificial means on any large river system.

2. That with partial control on any large river system the combined uses of reservoir for flood protection and other purposes is so antagonistic as to be inexpedient.

3. That reservoirs, for whatever purpose they may be constructed, will have minor favorable effects for most other purposes in that they will tend to equalize the stream flow.

4. That, in general, reservoirs should be built and operated for a single purpose when found financially advantageous for such a purpose, and that with few exceptions the use of reservoirs for combined services is not warranted except when they can be so used as not to interfere with the purpose for which they were constructed.

Boulder Dam Project on Colorado River

By Colonel W. Kelly

The Colorado has its source in the melting snows of the mountains of the Continental Divide.

Its drainage basin has an area of 250,000 sq. mi. and covers parts of seven states.

The Upper Basin, which lies above the junction of the main river with the Green River in Utah, has possibilities of development for both irrigation and power. The total area that can be irrigated in the upper basin probably does not exceed 4,500,000 acres, of which about one-third is now irrigated. This area lies from 4000 to 8000 ft. above the sea, and use of water for irrigation will always be limited by climatic conditions. Including diversions out of the basin, the use of water will probably never exceed 5,000,000 a. ft. per year.

The middle, or canyon section, of the river extends

from the junction of the Green to a short distance below Needles, Cal. In this section the river runs in a deep canyon so far below the general level of the land that irrigation will never be important. On the other hand, this section has power potentialities of over 4,000,000 horsepower.

The lower basin, below Needles, Cal., has considerable areas that can be irrigated. Power possibilities in this section are small and will always be incidental to irrigation. In this section lies the Yuma irrigation project of Arizona and the Imperial Valley of California, flood protection for which started all the controversy over the proposed Boulder Canyon project.

Flood Control

The big floods of the Colorado are due to melting snows on the head waters. They occur between March and July, usually reaching their peak in June. The maximum flow has been as much as 200,000 c.f.s. Floods from the Gila, which flows into the Colorado just above Yuma, are due to winter rains. While flashy, and of short duration, the Gila floods often have as large a maximum flow as those of the Colorado. They constitute, therefore, an important element in the flood problem. Reservoirs can be found to control the Colorado, but so far none have been found feasible to control the Gila.

Records of flood damages indicate that there is not much more danger of damage from a flow of 75,000 c.f.s. than from one of 25,000 c.f.s., but that when the flow exceeds 80,000 c.f.s., the difficulty in fighting its attacks upon its banks becomes greater. They also show that fluctuations of flow, especially on a falling river, are particularly dangerous. Reservoirs can be provided on the Colorado to hold its flood flow down to 75,000 c.f.s. or less; they can also be operated to reduce sudden fluctuations in flow. Finally, they can be used to hold the entire low water flow for three or four months so that repairs could be made in the dry in case the river should break into the valley again, as it did in 1905. This is all that reservoirs on the Colorado can do, and it is not enough. Means must also be found of providing a stable channel to carry the Gila floods safely through the delta into the ocean.

The speaker's studies indicate that 4,000,000 a. ft. of storage on the lower Colorado will give all the relief that can reasonably be hoped for from reservoirs. The Reclamation Service engineers recommend 8,000,000 a. ft. as being desirable. The Boulder Canyon reservoir will have a capacity of 26,000,000 a. ft., over three times the maximum estimated as desirable.

Analysis of the Boulder Dam Proposal

The principal elements of the Swing-Johnson proposal are:

1. A dam in Black Canyon just below Boulder Canyon and about 300 mi. upstream from Yuma, Arizona. The average head on the dam is to be about 550 ft. The dam will form a reservoir with a capacity of 26,000,000 a. ft. (at average flow it would require a year and a half for the river to fill the reservoir). Foundations of the dam will be on bed rock 127 ft. below present low water surface of the river. The estimated cost of the dam is $41,500,000.

2. Power plants to develop the water power that will be available at the dam. The construction of the plants is left optional with the Secretary of Interior. He may instead lease the water power. About 550,000 hp. will be available, and an installation of 1,000,000 hp. is contemplated. The estimated cost of the power plants is $31,500,000.

3. An All American Canal from Laguna Dam just above Yuma, Arizona, to the Imperial Valley. The estimated cost of the canal is $31,000,000.

4. A capacity of 8,000,000 a. ft. at the top of the reservoir is to be reserved for flood storage.

It is estimated that it will take seven or eight years to build the dam and the total cost of the project, including interest during construction, is estimated at $125,000,000. The bill provides that the Federal Government shall finance the entire project and its advocates claim that returns from the sale of power and irrigation water and from the lands benefited by the All American Canal will refund the entire cost in about 25 yr.

The principal objections to the project may be summarized as follows:

1. If carried out as planned, the project will put to beneficial use through the power plants all the water in the river. Based on decisions of the Supreme Court, it appears probable that no additional diversions of water in the upper basin could thereafter be made without paying damages to the beneficiaries of the project. The upper states have taken the stand that the only sure way to overcome this objection is to negotiate an interstate compact that will reserve a certain amount of water for the upper states. Such a compact was drawn and ratified by six of the seven interested states. Arizona, however, failed to ratify it and later Utah withdrew its ratification.

2. If the project were adopted, the low water flow below the dam would be increased to such an extent as to make possible and probable the irrigation of nearly 1,000,000 additional acres of land in Mexico. Any water put to use in Mexico without a treaty limitation will be practically impossible to withdraw for use in the United States. The water will eventually be needed in the United States and should not be made available to Mexico until a treaty agreement with respect to it has been reached.

3. The project is economically unsound and the Federal Government will never be able to secure repayment of a considerable part of the cost.

4. Flood control of the lower basin (the only justification for participation of the Federal Government in the project) can be secured in a more adequate manner at a small fraction of the cost of this project, and without incurring either of the first two objections.

Power

Even if everything breaks most favorably, it is hardly possible that the works contemplated in the Swing-Johnson bill can be built for $125,000,000. The Secretary of Interior has stated that the costs may run to $200,000,000, and considering the risks involved, unfavorable river and weather conditions might easily run them higher than that.

The power to be generated at the dam constitutes the main source of revenue from which repayment of the costs may be obtained. Even at the time proposed,

when water power was enjoying a boom, the project contained large risks of economic failure. Since that time, increased efficiency in steam-generated power, combined with lower fuel costs, makes it very doubtful whether the Boulder power project can carry itself even if it can be built within the estimates, and it is certain that it cannot carry any of the costs of the All American Canal nor of the flood protection.

Unused storage space at the top of a very high dam is manifestly costly to power revenue. If Boulder Dam be built as proposed with the top 8,000,000 a. ft. of storage reserved for flood control, the additional kilowatt-hours to be had by utilizing for power this lost head, at the return estimated by the Department of Interior, would finance the building of an 8,000,000-a. ft. flood storage reservoir at Tapock near Needles, Cal., 100 miles nearer the territory to be protected. In other words, if the project can be self-supporting, as claimed, sound engineering would indicate that it is better to build two dams, one solely for flood control and the other solely for power. Two dams would be good engineering but poor politics, because once the flood control were divorced from the rest, the Federal Government would limit itself to contribution to the flood control and would discard the power investment features as being none of its business and contrary to its fundamental policy of keeping out of business.

Solution Suggested

Satisfactory flood protection for the lower basin involves two elements:

1. Construction of a reasonably permanent and stable channel through the delta to the Gulf of California.

2. Flood storage on the Colorado with capacity of from 4,000,000 to 8,000,000 a. ft.

The first element is the one of more immediate importance, but, strange as it may seem, it has been almost completely lost to view in the fight for the Swing-Johnson bill. All efforts to have studies made by the Federal Government have been blocked by the advocates of the Swing-Johnson bill so that information is not available to make satisfactory plans or estimates. The most that can be said is that, based on the work heretofore done, it is probable that a satisfactory solution can be had for from $5,000,000 to $10,000,000.

The second element can be solved by a reservoir in the Mohave Valley with a dam near Tapock just below Needles, Cal. This site presents many advantages as a site for flood protection and re-regulation for irrigation of the lower basin. It is easily accessible, develops great capacity with a relatively low dam and leaves the entire canyon section of the main river free to be developed for power whenever the power is needed. Here again the Swing-Johnson advocates have thwarted all efforts to have an adequate investigation made by federal authorities. The foundations for the dam have not been explored, but the Santa Fe Railroad bridge across the river just above the dam site gives fair assurance that satisfactory foundations exist at a not excessive depth.

The best estimates available indicate that a flood control reservoir at this point with 8,000,000 a. ft. capacity will cost from $10,000,000 to $15,000,000, flowage damages included. Such a dam could be built in about three years.

Conclusions

Adequate flood protection can be given the lower basin by channel works through the delta and a flood reservoir in Mohave Valley at a cost of from $15,000,000 to $25,000,000.

Not only is there no physical or economical advantage in combining flood protection with either the All American Canal project, the Boulder Canyon power project or the Los Angeles municipal water supply project, none of which look like good investments at the present time, but if the flood project had not been saddled with such projects it is quite probable that it might have been an accomplished fact before this.

The separate flood project can be built at once without injustice to the other states in the Colorado Basin and without giving away water to Mexico. The Boulder Dam project cannot.

If the separate flood project be adopted, flood protection can be had in from three to four years, whereas, if combined with Boulder Dam, it cannot be had in less than seven years and may take ten or twelve years.

Progress and Trend in Hydraulic Power Development

By H. A. Hageman, Chief Hydraulic Engineer, Stone & Webster, Inc., Boston, Mass.

Progress in hydroelectric development has been particularly rapid in the past 25 yr. Successful methods have been devised for collecting and analyzing stream flow data and determining the resulting power and energy. Hydraulic structures are designed and constructed more economically. The detail design of dams and their appurtenances show marked improvement. Considerable attention has been given to drainage systems for dams to reduce internal water pressure or uplift on the foundation, which results from seepage through or under the structure. The effects of temperature changes within the dam have been investigated with beneficial results. More care is used in preparing construction joints in the attempt to secure the best possible bond between adjacent sections of concrete.

In addition to the plain gravity reservoir or spillway type, notable progress has been made in the design and construction of large arch and rockfill dams. The experiments being made in California with a thin section arch dam, 60 ft. high and 100 ft. radius, indicate promising results.

Hyroelectric machinery is less complicated and more efficient. The capacity of single main water wheel units has increased from 5500 hp. to over 70,000 hp., while the efficiency has been raised from approximately 80 per cent to 94 per cent. Today the modern reaction hydroelectric unit is of the single runner, vertical shaft type with generator mounted above and direct connected to the water wheel.

This type of unit, especially for large capacities, predominates on account of its fewer parts, simpler construction, lower cost and higher efficiency, as compared with the horizontal unit of the same head and power.

For heads up to approximately 50 ft. the propeller type runner is fast displacing the Francis wheel. This runner, while somewhat less efficient than the Francis wheel, operates at approximately 50 per cent higher

speed and is somewhat cheaper; the largest saving, however, is from the decrease in size of generator and power house.

Impulse wheels for main units are invariably used for heads of more than 1000 ft. Larger capacity units are usually of the two-runner, two-bearing, overhung type, one runner being mounted on each end of a single horizontal shaft with the generator between the runners and the supporting bearings. Impulse wheel units of the general design described, of 40,000 hp. capacity are in commercial service, and units of 56,000 hp. designed for 2500 ft. head are now being constructed. Vertical shaft impulse wheels are uncommon but not impractical.

The operation of the power plant has kept pace with the general advancement. More attention is given to scientific methods for using pondage and storage. Regular inspection and maintenance schedules are followed, with the result that greater utilization of the power and energy from the stream is obtained at less cost.

Developed water powers are operated as isolated plants or in parallel with other prime movers. It is apparent that the isolated water power plant can only furnish continuous power up to the amount produced by the wheels from the low or prime flow of the stream, and the amount of this capacity is dependent on the load factor of the system and the pondage available.

There are many examples of developed water powers operating in parallel with other prime movers, thereby utilizing the primary as well as large blocks of secondary power and energy in the system which they supply. Notable developments of this kind are in operation, such as Keokuk, Iowa; Big Creek and Pit River, California; Holtwood, Pennsylvania, and Bartlett's Ferry, Georgia. The hydroelectric development now under construction on the Susquehanna River at Conowingo, Maryland, is also of this type.

The Conowingo power site, if developed to supply power and energy as an isolated plant, would be uneconomical. The prime power of the Susquehanna River at this location, under an annual load factor of 50 per cent, would be about 55,000 kw., but when the proposed plant is operated in conjunction with the Philadelphia Electric Company's system, as now planned, the initial installation of seven 40,000-kv.a. units will replace approximately 190,000 kw. of steam capacity and will economically deliver to the system at Philadelphia about 1,280,000,000 kw-hr. in the average year, over a transmission line approximately 70 mi. long. It is estimated that this enormous amount of energy will conserve about 750,000 t. of coal annually.

A new method which is becoming popular for utilizing the wasted energy at inaccessible power sites on small streams, where the capacity is such that their development would be uneconomical if a regular operating force were required, is the electrically controlled automatic station. This type of station is usually electrically connected to and controlled from a distant central station employing the operating force. It may be fully or partially automatic, depending upon flow conditions of the stream and the service required. Reliable devices to control the operation of the hydroelectric machinery in automatic stations have been developed to such an extent that this type of station is entirely practicable.

Automatic hydroelectric stations containing one or more units having capacities up to several thousand kilowatts, are in satisfactory commercial operation.

It is customary to think of a water power as utilizing only the fall of a stream, but at present there is considerable discussion concerning the development of hydroelectric power from the tides of the ocean. There is no doubt that in some locations where the rise and fall of the tides is great, large blocks of prime power can be developed. Whether projects of this kind can be successfully carried out will depend on the cost of the energy as produced and delivered to points of use, as compared with the equivalent energy obtained from some other source.

During the recent New England flood, the benefit of storage development was clearly shown in the Deerfield River in Vermont and Massachusetts. The peak of the storm, which amounted to 9 in. in 24 hr. at Somerset, Vt., passed over this watershed without causing any flood damage, while all adjacent river valleys without adequate storage facilities suffered seriously.

The power needs of our industries and public utilities are ever increasing. The requirements will be met by further power development and by combinations and interconnections of both hydro and steam power systems. Such combinations and interconnections will result in greater economy and flexibility in management and operation and will eventually lead to the complete realization of the idea of the super-power system.

With the increased merging of power companies, there will be a tendency to create more Federal and State regulatory boards. Herein lies an important problem which must be solved satisfactorily if new power development is to be encouraged.

Operating Experience with High Pressure and High Temperature Steam

By Geo. A. Orrok, Consulting Engineer, The New York Edison Company

Five years ago, in a paper on the Commercial Possibilities of High Pressure and High Superheat in the Central Station, I examined the effect, on the boiler, piping, valves and turbines, of the increasing values of pressure and temperatures, then contemplated by many designers and operators of central stations. I concluded that pressures of 1200 to 1500 lb. were commercial and could be used with little difficulty, but the temperatures in excess of 750 deg. might offer difficulties if ordinary materials were used.

Since then many high pressure boilers, with their attendant piping and turbines or engines, have been installed and operated for varying periods up to five years that have now become history since that paper was written.

At that time (1922) the only really high pressure boiler in use was the experimental boiler of Schmidt and Hartmann which had been operating for 14,000 hr. at between 700 and 900 lb. pressure and giving little trouble. Blomquist in Sweden had been working his revolving tube boiler with good success and had installed two boilers at about 1000 lb. pressure in two industrial establishments. North Tees was running at 450 lb., the Joliet station at 400 lb. had been put in service the year

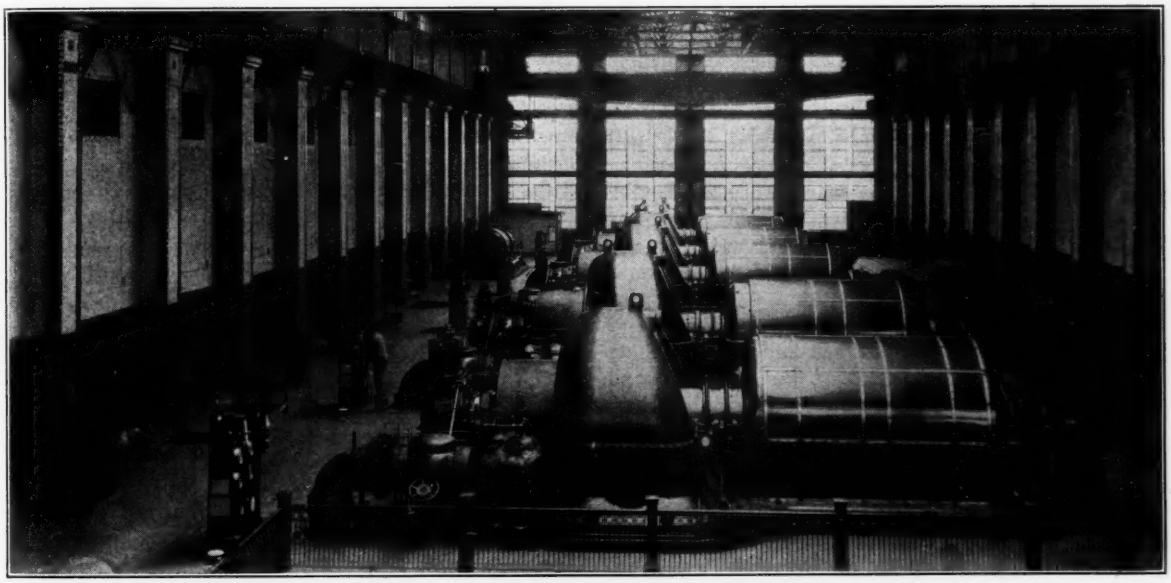
before and Gennevilliers also at 400 lb. was running, but going through the breaking-in period.

At the present time we have in this country six stations using pressures between 500 and 650 lb.—Philo, 1924; Crawford Ave., 1924; Columbia, 1925; Waukegan, 1927, Twin Branch, 1925; Stanton, 1927. Two 1200-lb. stations: Edgar, 1925; Lakeside, October 25, 1926. Besides these plants there are two smaller 1200-lb. boilers in service, one at Bridgeport, Conn., and Laurel, Miss.

In Europe the Amsterdam station is using 600 lb., Langerbrugge 750 lb., Klingenberg 550 lb. and Charlottenburg 500 lb. pressure. There are two Benson boilers at Siemensstadt, one for 200 lb. and the newer and larger boiler at the Cable Works operating at about 2800 lb. Borsig has operated its boiler at 850 lb. since 1924, while Hartman has three boilers, one a very good sized boiler for the chemical industry. Sulzer's 1400-lb. boiler has been in service since 1925. Blomquist has built a number of his revolving tube boilers for use in paper mills and other industrial works. With such a wealth and variety of material, some of which extends over 20,000 hr. of use, it would appear useful to collect experiences and see how nearly the conclusions of 1922 have been justified by the facts in the case. To do this the reports of the Prime Movers Committee of the N. E. L. A., and the proceedings of the Union Internationale des Producteurs et Distributeurs d'Energie Electrique, and the various operating papers before our American Engineering Societies have been examined and this body of facts has been supplemented by personal letters from many of my friends in charge of or responsible for high pressure installations.

All reports agree on one fact which recurs with remarkable regularity in these reports: Operating troubles are no greater with high pressures than with the ordinary 200 lb. pressure so long standard. There seems to be no difficulty in handling high pressure steam with apparatus of the conventional type made proportionately heavy. No more troubles with our 750-lb. plant than with our 300-lb. plant; troubles with the conveyors and feed pumps but not with the boiler; no troubles with the boiler but had to change the type of gage glass used. Trouble with economizer section but not with the boiler. It thus seems to be established that of the many high pressure installations, no operator has encountered difficulties due to the high pressure while some report an increase in steadiness of action.

Without exception all operators agree that the installation of the high pressure they use has been justified by results, thermal and commercial and a number are installing more machinery of the same kind. These repeat orders have been given in base load plants, in bleeder or high pressure plants exhausting into process or low pressure mains, where the turbine acts as a reducing valve, and also in stations without base load as at Langerbrugge and Charlottenburg. It would thus appear that in these conditions, the extra first cost of the high pressure apparatus was not very large, and, quite possibly, of the order suggested in my 1922 paper.



TURBINE ROOM OF THE LAKESIDE STATION OF THE MILWAUKEE ELECTRIC RAILWAY & LIGHT CO.

The range of fuel cost runs from $2.50 to over $8.00 per ton in the various plants but apparently makes little difference in the commercial aspect of the case since they all report commercial savings.

It is interesting to note the places where troubles were expected but did not develop. It was first thought that safety valves might give trouble and pilot safety valves were fitted to blow at a lower pressure. Experience has shown that these valves are as reliable as those operating at a much lower pressure and the pilot valves have been removed. Difficulties were expected with the water level in drums when load changes occurred. These difficulties have not manifested themselves except in a minor way, and are not nearly so noticeable as in lower pressure boilers. Troubles were expected from the expanded joints between tube and drum. These troubles have not developed. Superheater and reheater troubles were looked for but have been no more prevalent than in other installations. The large amount of energy in the

resuperheater piping and resuperheaters was believed to be a source of trouble, much thought and money being expended on this system. No troubles of serious nature have been reported from this source. Piping and valve difficulties were believed to be incidental to high pressure work but very few troubles have been reported; the smaller sizes used with the high pressure steam have avoided this difficulty.

Unexpected troubles of various kinds have developed and have been overcome in the same way as when in earlier days similar troubles were corrected in boilers working under ordinary pressures. Hand hole gasket-troubles have been reported from a number of sources. This sort of trouble has always been with us and is soon eliminated. Feed pump troubles have developed in nearly every plant and have been corrected but not as easily as the gasket trouble. Feedwater regulators have given some trouble but were soon put right. Gage glass troubles have been reported from nearly all plants. These troubles have ceased when heavier and better designed fittings have been provided. Some trouble has been experienced from the leaking of cast-steel fittings but this can be as readily overcome as when 200 lb. pressure was the standard.

A number of operators have reported that finely powdered solids have been carried over with the steam into the turbine, where it has made the usual trouble by deposition in nozzles and erosion of blades. Just how this material is carried is not known but when the concentration of the boiler water is reduced to the proper point this difficulty should disappear.

Turbine difficulties have been of the usual character. Vibration, much smaller in extent and much less destructive than in the larger units, has been the main trouble with European designs. Gland troubles have been reported but slight changes in type of gland removed this difficulty. No troubles have been reported that could definitely be laid to high pressures, except certain heat deformations of nozzles due to unexpectedly high superheat at Gennevilliers. The machines for a higher pressure than 600 lb. are all small and quite rugged, 10,000 kw. [illegible] the largest unit yet built. The liability to trouble is small indeed. A number of operators report a slight oxidation of turbine blades and nozzles as well as the inside surfaces of the casings exposed to the high pressure steam. The phenomenon appears to be similar to the thin reddish brown oxide found in the interior of our high pressure superheated steam pipes. This scale is thin, hard and intensely adherent. Apparently it does not thicken with time of exposure but acts as a protective coating. From the reports we may conclude that there are no serious difficulties in the operation of turbines at pressures between 1200 and 2000 lb. per sq. in.

We have one installation using high pressure where the superheat temperature has been higher than the customary 700 deg. to 750 deg. F. This is the Langerbrugge Station of the Centrales Electriques des Flanders where the standard superheat temperature is 850 deg. F. The station had been using this temperature over 2 yr. when I had the opportunity of examining one of the superheaters and has now been running about 4 yr. On my examination in August, 1926, the condition of the superheaters presented nothing out of the ordinary. Indeed they might have been running at 650 deg. to 700 deg. F. and were similar in appearance to the lower pressure and temperature superheater now running in our older stations. Several other plants have reported sporadic temperatures of 800 deg. to 1000 deg. F. for a few hours without serious consequences. A number of operators report replacing a few superheater coils but the replacement was not due to high temperature or pressure and is not more common than in the 200-lb. to 500-lb. plants.

Turbines and piping and valves used for high pressure have not departed materially in design from the lower pressure standards. Where higher temperatures than the usual 700 deg. to 750 deg. F. are concerned, the expansion problem must be more carefully considered. Very probably up to 800 deg. to 850 deg. F. the usual qualities of steel will perform satisfactorily, but some operators report the use of alloy steels for shells, tubes and castings. Riveted drums have not been used above 650 lb. except at Langerbrugge where some trouble has occurred from leaks. It has been stated that these drums are to be replaced with welded or forged drums. All of the remainder of the high pressure jobs use forged or welded drums or else no drums at all. Such boilers as the Benson and Atmos only require collectors, while in the Hartmann and Loeffler boilers the drum is away from the fire and the heating is internal through the agency of superheated steam.

Conclusions

1. There appear to be no serious difficulties in the operation of plants using pressures ranging up to at least 2000 lb. per sq. in.

2. Four years experience in continuous operation of superheaters raising the steam temperatures to 850 deg. F. with ordinary steel superheater tubes has proved such operation commercial as no serious difficulties have been encountered.

3. Alloy steels for tubes, shells and castings are available for more difficult operating conditions than have heretofore been tried out in practice. Boiler companies state they are ready to guarantee service up to 900 deg. F.

4. Operators report both thermal and commercial economy in the use of higher pressures and this is evidenced by repeat orders for similar apparatus.

5. Commercial results have not been reported quantitatively and we are no nearer an answer as to the most economical pressure and temperature to use for any given case.

Trend and Development in Steam Generation

By Thomas E. Murray

Steam is such a vital influence in our progress that the attention of man has been long engaged in improving the methods of its production. We are all at least passingly familiar with the larger steps taken toward this end. At first the boiler consisted of a simple pot in which water was heated in bulk. Later developments divided the water into smaller and smaller parts to permit a more widespread and quicker penetration of the

heat. In recent years refinements have been made in the methods of arranging the water spaces and of directing the flow of combustion gases.

We have come to look upon the water tube boiler as the most suitable type for power purposes. The size, shape, arrangement and spacing of tubes have all been stressed by different designers resulting in a wide variety of boilers different in some one or more of these details. The control of the flow of gases across the tubes has been accomplished by means of baffles more or less ingeniously devised in the endeavor to insure the greatest contact of the moving gases with the surface of the tubes.

The details of construction, the means and materials for fabricating the drums, headers, water boxes, tubes and smaller parts have been painstakingly worked out during the course of years.

A great deal of technical thought has been brought to bear upon the problem of transferring the heat of the gases to the water and the influence upon it of various factors, such as the circulation of water, the flow of gases, and the distribution of the heating surface.

Personally I do not believe that we shall ever standardize on a given steam pressure for power stations. We shall have 400, 600, 1200 lb. and possibly higher and each pressure will be the most economical one for the particular conditions encountered in the design of a certain station. We have never found any justification for higher pressures than 400 lb. in our New York stations due to our load conditions; however, we would not hesitate to go higher if conditions changed.

The binary vapor system involving the use of materials which have high temperatures of condensation at normal pressures, such as, for example, mercury and diphenyl-oxide have been proposed and tried with some success in the attempt to convert a larger portion of the heat value of the fuel into electrical energy. The overall thermal efficiency is considerably greater than in our ordinary cycle of power generation.

There is another method of steam generation which has had some application abroad and which also makes use of an intermediary fluid between the water to be converted into steam and the fuel, but whose object is an entirely different one than that of the mercury boiler. I refer to the Hartmann boiler in which water in a closed system is heated in a furnace and circulated through a coil in a drum where it generates steam from an independent source of water. The object in this case is to secure steam at high pressure and avoid the difficulties attendant upon a high pressure steam drum exposed to the direct action of the fire.

There is no makeup water added to the closed system so that the possibility of scale formation in the boiler tubes is avoided.

In the Loeffler boiler a somewhat similar scheme is used for avoiding the exposure of the drum to the furnace, but in this boiler instead of a closed system for circulating the water in the boiler to the drum, the steam generated in the boiler is discharged below the surface of the water in the drum and mixes with it.

Another departure in the ordinary methods of steam generation is that used in the Benson boiler. One of these boilers having a capacity of 250,000 lb. of steam per hour has been recently installed at Gartenfeld, Germany, operating at approximately 3200 lb. per sq. in. with steam at 800 deg. F. At this pressure steam is at its critical vapor pressure so that the fluid may exist either as a gas or liquid, and can pass from one state to the other without ebullition. The boiler in this installation consists of a cylindrically shaped furnace, fired by means of powdered coal admitted at the top and center of the cylinder, and directed downward into the combustion space. This space is surrounded by a pipe coil. The feedwater is pumped under pressure into this coil at one point and the heated fluid taken from the opposite end of the coil. It is then directed into a superheater coil placed in the annular flue which surrounds the furnace, the superheated fluid thence being sent into the piping system.

We are at the present time working on plans for boilers each having a capacity of 800,000 lb. of steam per hour. We will next install boilers of at least 1,000,000 lb. of steam per hour and I expect we may soon have units large enough to supply all the steam required by the 200,000 kw., 300,000-kw. turbines, or whatever size the future machines may be.

A few days ago I made some figures which may be of interest to you. They serve to illustrate the remarkable strides which have been made in reducing the size of boiler plants. I used as a basis of comparison the East River Station in New York. This plant will have a capacity of approximately 1,300,000 kw. If we had to use the boiler of 20 yr. ago and the boilers were laid side by side in one row with an aisle between each battery, the row would extend from 14th Street to 96th Street, a distance of 19,000 feet. Boilers of 1920 vintage would extend from 14th Street to 29th Street, a distance of 3828 feet. Boilers of 800,000 capacity would extend less than one-fifth of this distance.

Boiler plant design may become stabilized and fixed, but I do not think it will as long as the good, healthy competition and vigorous growth which we have been experiencing continues. There are many radical changes yet to come, and the whole field of coal distillation is still before us.

Detroit Edison Plans 1928 Construction

CONSTRUCTION PROGRAM for 1928 of The Detroit Edison Co. will be at least as large and possibly larger than for 1927, according to a recent statement by the Detroit Edison Synchroscope. The 6th and last 50,000-kw. turbo-generator unit for the Trenton Channel Plant will be installed, giving this plant a total capacity of 300,000 kw. Work on the No. 3 power house at Delray will be conducted so that an installation of 100,000 kw. will be ready there late in 1929. At the Marysville plant, the 5th turbine, a 30,000-kw. machine will be installed to go into service about May 15, thus giving this station a total rated capacity of 100,000 kw. Four new substations will be built and additions will be made to a number of existing sub-stations, including, Amsterdam, Cortland, Grand River and Hart. A new 120,000-v. steel tower transmission line will be built from Trenton Channel to West Warren and one from Marysville to Northeast. Extensions, services, transformers and meters will be provided for 27,000 new electric customers and gas service will be extended to Marine City and Algonac.

EDITORIAL COMMENT

Public Utility Power from Industrial Plants

Can the central station lion and the industrial plant lamb lie down together? Many people have the impression that they cannot, except when the lamb is inside the lion. Nevertheless, engineers know that they have lain down together on many occasions, the lamb on the outside and heartier than ever because of its association with the lion, whose ferocity has been much over-rated.

Let us abandon the metaphor, however, before it becomes too involved. What we refer to is the practice in many cases of interconnecting industrial power plants with public utility transmission systems so that the former can feed their surplus power into the system, preferably at times of central station peaks. Since this scheme has been discussed on many previous occasions in these columns, we were much interested in an item in the latest statistical report of the N. E. L. A. to the effect that, according to the U. S. Geological Survey, there is a total of 316,000 kw. of generating capacity in manufacturing plants contributing to public utility supply. These plants, during 1926, furnished 881,900,000 kw-hr. for this purpose.

Figures are not available to show how fast interconnections of industrial and central stations are increasing but our own observation indicates that they are growing slowly and steadily. Of course, any increase depends on the characteristics of the plants under consideration and unless these characteristics are right for both plants, interconnection cannot be attempted.

Possibly the metaphor of the lion and the lamb is not entirely accurate; the lamb tends sometimes to become a young lion. Yet the feeling still persists in some quarters that the good industrial plant cannot allow the central station to have anything to do with it, for the least concession will mean the taking over of the service by the central station. We do not believe this feeling is well founded, however, because the public utility knows that, under the proper conditions of process steam utilization and power demand, the industrial plant can make a kilowatt-hour cheaper than the central station can. When an industrial plant of this type has any surplus power, as in steel mills, it may be to the advantage of both parties to co-operate. Of course, there is always the question of how much this industrial power is worth and here some knotty problems have arisen. They have been mostly financial rather than engineering problems. The important thing is that they have been solved so successfully in many cases.

Not long ago an eminent public utility engineer, admitting that he would probably be burned at the stake for heresy, treason, or possibly mayhem, said that in his opinion it would not be many years before the power system of the country would be one vast network of interconnections with industrial plants feeding into these systems whenever possible. This scheme, he continued, is being rapidly developed in Germany, where new industrial plants are designed with the definite object of doing this.

So, without meaning to imply that the central station combines the ferocity of the lion with his strength or that the industrial power plant combines the meekness of the lamb with his smaller size, we feel that under proper conditions the lion and the lamb can lie down together with the lamb outside. This act of amity, it would seem, is destined to occur even more frequently in the future than it has in the past.

Examinations for Operating Engineers

Examination for license to operate engines and boilers is primarily a safety precaution to avoid the danger of entrusting high pressured steam apparatus to incompetent men. Its purpose is to establish police powers for the protection of the public. Such examinations, however, also have a tendency to raise the standard of proficiency of operators, but it must be clearly understood that this, although important, is a secondary consideration.

Frequently questions for examinations are taken from experiences of boiler inspectors. When such experiences concern fundamental principles they may be the bases of legitimate questions but when they involve very special and peculiar situations, their use is questionable. It should be understood that most operators are not accustomed to being examined and are more or less embarrassed when they come up for examination and, therefore, are not as likely to give a proper answer to a given question as they would properly cope with a situation involving such a question when set before them in their daily practice.

An example of this kind is the following question recently given in the engineer's examination in an eastern state. In a water tube boiler having three steam drums, only two of which were provided with gage glasses, what would cause the water in the center drum to be drawn down to a lower level than that of the outer drums? The basis of this question came from a condition set up when a repair man stuffed the steam opening with clothes in order to prevent hot water from dropping from a leaky valve. Failure to remove the material from the opening caused an increase in pressure and thus forced the water out. Is this a fair question? It would represent a decidedly unusual condition.

It is believed that most examiners are honest, earnest and fair. But experiences with questions put to us by

many of our readers who claim to have failed in examinations because they could not give the correct answers indicate that there is a real need for greater care in the preparation of examination questions for firemen and enginemen and that a closer adherence to the fundamental reason for giving those examinations is desirable.

Another type of question frequently given lacks sufficient information to permit of intelligent answer. As an example we have: How fast must a centrifugal pump run in order to fill a discharge pipe? In this question no mention was made of the size of either pump or pipe. Not long ago an engineer was asked in an examination, "what is there about an Ames engine that is different from others?" A perfectly correct answer would have been "the name plate," but this is obviously not the answer desired. Another question recently put is, "If, after centering the piston rod of a Corliss engine having a built-up piston, your follower plate would not go on, what would be the trouble and how would you get the follower plate on?" Clearly greater detail is needed. If the applicant had an actual situation of this kind, there could be a real demonstration of whether or not he could cope with the condition. This opens up the question as to the desirability of having as part of an engineer's examination, some actual demonstration of his ability.

Questions are sometimes so vague or ambiguous that an examiner would have undue latitude in checking answers and could throw his favor, if he wished to, toward a particular person.

Examination for license, particularly when there are different classes or grades, lends itself admirably to the selection of properly qualified men when such examinations are held in a fair and unbiased manner and every precaution should be taken to maintain such examinations on a high plane so that not only will the public be safeguarded, but that an incentive to improve will be set up in the minds of every operator.

Interchange of Information

During the early participation of our country in the World War, it was very necessary to produce ships, equipment, ordnance and supplies as quickly as possible. There was no time to establish research to determine the one best way to execute a function and fabricate a part. Nor did our country attempt at once to perfect its ship building plants one at a time. It made, instead, a survey of the country to find where, for example, the best method of riveting was practiced and then adopted this method as standard in all of the shipyards it controlled. It next investigated bolting up methods in a similar manner and adopted the best method found as standard. In this way many plants cooperated, each contributing one or more excellent methods to the industrial caldron, thus reducing wasteful methods and making possible unprecedented production.

Industry in general, but the power industry in particular, would benefit much if a central agency could be established whose function it would be to collect information regarding not only the best methods to pursue but also concerning the methods that have failed. It is quite as important to know what to avoid as to know what to do. In this way, by pooling experiences, repeated learning by trial and error, which is very costly, would be considerably reduced. Much expense caused by repeating errors made by former investigators, could be avoided if one could, by consulting an industrial library find collected together practically all that had been accomplished—good and bad—in any branch of industry.

Industrial magazines attempt to function as far as possible as purveyors of best methods; their information must come from gathered experiences. In the power field, central station operators generally respond readily in furnishing information for investigations made for the benefit of those who are in that field but difficulty is experienced in obtaining similar data from industrial power station operators. This may be partly due to the greater lack of refined organization and therefore of adequate records in the industrial field, but it is also due to a lack of appreciation on the part of industrial plant operators that industry in general has advanced far beyond the trade secret stage and that contributions made to the stock of ideas and experiences in the power field not only aid in raising the standards in that field but reflect credit upon the donors and return due rewards.

High Heat Liberation in Small Furnaces

Turbulent pulverized coal burners have undoubtedly been one of the major factors in the progress of pulverized coal, particularly in the reduction of furnace sizes. There is still considerable discussion as to whether or not reduction in furnace sizes is necessary or advisable in stationary practice.

These arguments, however, do not affect conditions where furnace size is determined by other factors, for instance in marine work or remodeling when furnace size cannot be increased. For this reason the test results on Scotch marine boilers, as reported in this issue, are particularly valuable. They represent the high water mark for coal burning and practically equal heat liberation and efficiency results obtained with oil. Small furnaces may not always be desirable but it is well to know the ultimate results that can be expected under extraordinary conditions.

Unit Mills at Cahokia

Probably no central station addition has aroused more interest in engineering circles than the new addition to Cahokia where the central system has been abandoned in favor of unit mills.

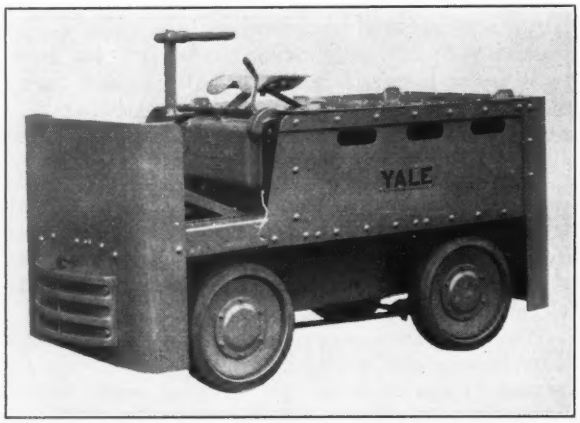
This change was based on operating experience with both types in St. Louis. Either system may be successfully used with midwestern coals but it was felt that the unit system offers special advantages in lower investment costs, gives equal furnace efficiencies with less labor, simplifies the installation and is cleaner, quieter and probably more safe to operate.

Whether all of these conclusions have or will prove true is not yet known. Results of tests made on the new boilers, however, are very promising. Operating results to date have been entirely satisfactory and the unit system dependable. The unit system is not yet supreme in the field but if successful at Cahokia, the installation will prove to be one of the strongest arguments of the unit mill advocates.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

New Yale Four-Wheel-Drive Tractor

AS SHOWN HEREWITH, the Yale model K24C four-wheel drive tractor has been brought out to meet the demands for an electric driven tractor of heavier type. The machine is capable of an ultimate



MODEL K24C TRACTOR HAS DRAWBAR PULL OF 4000 LB.

draw bar pull in excess of 4000 lb., depending upon road surface conditions, and will operate a continuous draw bar pull of 1000 lb. without danger of overheating. By driving all four wheels of the machine, it is possible to get the maximum of traction with the given overall weight of the machine.

Of equal importance, on the model K24C, are the four wheel brakes. These brakes operate through the differentials so that they properly equalize regardless of the conditions of the lining. The spring which automatically applies these brakes when the operator either raises his foot pedal or else steps off the machine, is directly connected to the brake shoes themselves, so that any disarrangement of the linkages between the foot pedal and the brake lever would in no way hazard the driver of the machine. If this linkage should fail, the brakes would immediately apply and warn the driver that something was wrong. If the operator leaves his machine or falls from his machine through some accident, the brakes would automatically be applied and the current opened.

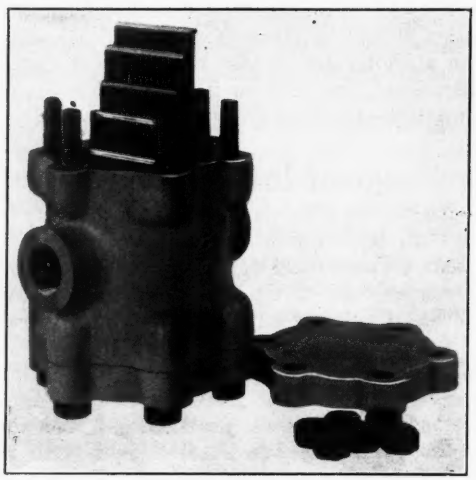
Steering on this tractor is accomplished through a lever handle so arranged that the handle may be folded up out of the way if the driver wishes to leave his seat. The steering knuckles on all four driving wheels are each equipped with a ball flush bearing.

The driving units applied in this truck consist of two standardized units connected in parallel at the controller. This machine is regularly furnished with a 48-v. motor, and a 23 to 1 gear ratio.

On the frame, pressed steel side members or main supporting members are strong and integral parts with the axle yokes, to produce a member capable of standing jolts and jars in addition to the usual bending stresses to which it is subjected. The bumpers are made of ½-in. plates and a triple bumper casting front and rear gives a range of coupling height that will meet practically every requirement. The new model K24C is a product of the Yale & Towne Mfg. Co., Stamford, Conn.

New Purifier for Small Pipe Lines

USING THE SAME principles that have been employed in the Tracyfier, a smaller purifier known as the Pipe Line Tracyfier has been developed for use



PIPE LINE TRACYFIER FOR 1½-IN. LINE

in several sizes of air, steam, or gas lines up to three-inch.

In saturated steam lines it is designed to remove all moisture from the steam, delivering what is called standard specification steam, free from all solids, both soluble and insoluble. Samples of condensed steam passed through this unit have shown, it is stated, no more than nine parts total solids per million, which is the tolerance to cover dissolved copper and iron from the test condenser, unavoidable dust contamination during the collection of the sample and its evaporation and

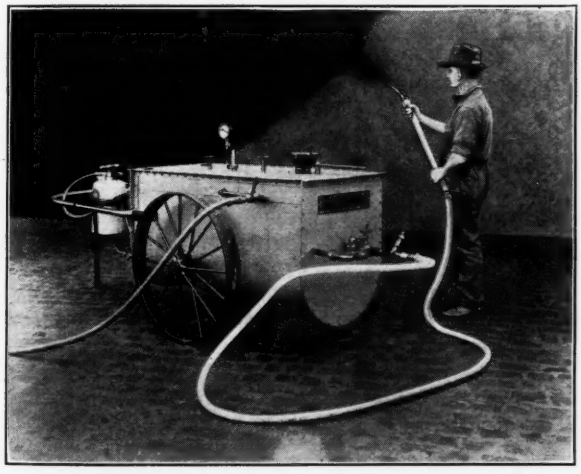
unavoidable errors in the laboratory determination of total solids. Throttling calorimeter tests with this unit, according to its manufacturer, at all times show 100 per cent dry steam, plus or minus not more than 0.2 of 1 per cent, based on the determined normal of the calorimeter. This permitted variation is the tolerance for unavoidable variations in radiation and thermodynamic changes.

Many uses are suggested by the manufacturer for a purifier of this size, such as in steam lines to gas producers to maintain a more uniform hydrogen content in the gas; in the steam lines leading to the tar burners on open hearth furnaces, or in air lines to clean air for pneumatic tools. Placed ahead of laundry or paper driers, the purifier has been found to increase the output of the machines.

The Pipe Line Tracyfier is made and sold by Andrews-Bradshaw Co., a division of Blaw-Knox Co., Pittsburgh, Pa.

Bitumen Gun for Applying Protective Coating

DESIGNED for applying protective coatings of hot tar, asphalt, enamel, waxes, paraffines and similar materials to foundations, walls, roofs, tanks, steelwork, penstocks and other surfaces, the Quigley Bitumen Gun



BITUMEN GUN IN OPERATION APPLYING COATING TO CONCRETE WALL

has been placed on the market. This is designed to shoot liquid of any consistency or temperature through insulated metallic hose any distance up to several hundred feet from the gun.

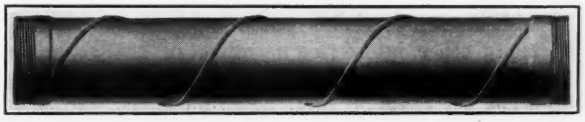
The gun itself consists of a cast-iron cylinder from which the material is forced by a piston. At 60 lb. pressure, 15 c.f.m. of air will operate the gun, but this simply actuates the piston, no air comes in contact with or is entrapped with the material, which is atomized by a mechanical process. A small portable garage compressor operated by gasoline or electricity will be sufficient if no other air supply is available. The gun is enclosed in a steel housing mounted on wheels. Its capacity is 15 gal.

The equipment is designed to be operated by two men, one at the nozzle, the other charging the gun and regulating air supply. For hot spraying, preheated material is put in through a charging opening, a quick-acting vent valve is closed and another valve opened to admit air back of the piston. Temperature in the gun is regulated by a small, self-contained kerosene burner, a large scale thermometer being provided to guide the operator. After the gun is completely discharged, compressed air sends the piston back to the loading position. Material is sent through the hose with a temperature drop, it is stated, of 3 deg. for each 25-ft. length of hose. When the work stops, the gun is drained of unused material and the hose is cleaned by hot compressed air, provided by a heating coil in the housing.

For spraying paint, whitewash or other cold plastic mixtures or liquids, the gun is intended to be equally adaptable. It is manufactured by Quigley Furnace Specialties Co., 26 Cortlandt St., New York, N. Y.

Naylor Pipe Now Made of Toncan Iron

COMBINATION of the advantages of Naylor Spiral Lock-Seam Pipe with Toncan iron has resulted in Naylor Spiralweld iron pipe, made of Toncan iron, as shown herewith.



SPIRAL WELD IRON PIPE WITH THREADED ENDS

Naylor Spiralweld iron pipe is stated to be the only Toncan iron pipe made to wrought pipe standards, sizes 4 in. to 12 in., 20-ft. lengths, threaded ends for standard screw fittings, and flanged ends for standard flange fittings, black, galvanized or asphalt dipped.

To satisfy the demand for this pipe for high pressures, it was necessary to make it over. The spiral seam was therefore welded to the wall of the pipe. This additional strength, due to the tightly locked and rolled four-ply seam, is not necessary in most instances, but serves as a double safeguard for high pressures.

For some time past, its manufacturer, the Naylor Spiral Pipe Co., 1230 E. 92nd St., Chicago, Ill., has made it a practice to forward a short length of pipe to anyone interested in comparing it with other types.

December 1, 1927, New York Power Show Directory

ON PAGE 1281 of the December 1, 1927, issue the statement in the directory of exhibits at the New York Power Show relating to the display of the De Laval Steam Turbine Co., booths 540 to 543, should read as follows:

"The exhibit will feature a centrifugal pump especially developed for feeding modern high pressure boilers. To reduce the leakage between stages with pumps having split diaphragms, the diaphragms of this pump are built in one piece and make metal to metal joints with the casing at their peripheries, being held tight by water pressure."

Joint Session with London, Feature of A.I.E.E. Meeting

ALTHOUGH separated by 3000 mi. of North Atlantic ocean the members attending the Midwinter convention of the American Institute of Electrical Engineers in New York and the British Institution of Electrical Engineers in London held a joint session on Thursday, Feb. 16, at which speakers in both cities were heard by both groups. This event, made possible by the new New York-London telephone circuit, was the high point of the Midwinter Convention of the A. I. E. E. and demonstrated in an eloquent manner the marvelous achievements of the electrical engineer. It was fitting that the first large scale demonstration of trans-Atlantic telephony should have been held before those responsible for its development. Greetings were exchanged between Bancroft Gherardi, president of the A. I. E. E., and Archibald Page, president of the British Institute of Electrical Engineers, as well as between officials of the American Telephone and Telegraph Co. and the British Post Office. This demonstration was held at the Communications Session in connection with the presentation of two papers on transatlantic telephony by O. B. Blackwell and K. W. Waterson, both of the A. T. & T. Co.

This communications session, however, was only one of many other interesting meetings of the Midwinter Convention which was held Feb. 13-17. As has always been characteristic of A. I. E. E. meetings, the papers presented covered an enormous range of activity—from considerations of the earth's electric charge on the one hand to such practical matters as the arc welding of bridges.

Altogether, there were seven groupings or classifications under which papers were presented, each group in most cases constituting a session. These were as follows: 1. Electrophysics and Dielectrics; 2. Interconnection and Its Effect on Power Development; 3. Electrical Machinery; 4. Communications; 5. Control and Protective Equipment and Substations; 6. Arc Welding and, 7. Miscellaneous Technical Subjects.

To those interested in the generation and transmission of power, the session held on Tuesday, Feb. 14, on Interconnection and Its Effect on Power Development was of outstanding importance. At this session, four papers were presented as follows: The Conowingo Hydroelectric Project of the Philadelphia Electric Co.'s System, by W. C. L. Eglin; Progress and Problems from Interconnection in the Southeastern States, by W. E. Mitchell; Some Aspects of Interconnection on Pacific Coast, by P. M. Downing; and Interconnection and Power Development in Chicago and the Middle West, by H. B. Gear.

This group of papers, with the discussions of many noted engineers, without doubt constitutes the most complete and up-to-date consideration of the whole problem of interconnection yet made. Owing to the sudden death of the author, the Conowingo paper by W. C. L. Eglin was presented by N. E. Funk, assistant chief engineer of the Philadelphia Electric Co. This paper covered briefly the constructional features of the Conowingo project and then discussed in greater detail the physical aspects of the interconnection between Conowingo and other adjacent power systems.

The paper by P. M. Downing on Pacific Coast Interconnection was presented by J. C. Parker of the Brooklyn Edison Co. in Mr. Downing's absence. A feature which this paper emphasized was that interconnection does not necessarily imply capital consolidation of the power supply systems involved.

Naturally, this group of papers invoked much discussion. Discussion was led by Chas. L. Edgar of Boston who compared the interconnection of power systems to the spread of automobile highways throughout the country and to the idea of a unified sleeping car system, such as operated by the Pullman Co. A. C. Marshall of the Brooklyn Edison Co. called attention to the value of "diversity" with respect to time. "Some think that diversity in time is not under control," said Mr. Marshall, "but it is conceivable that for the sake of diversity permanent changes in time may be made, as was done when 'Standard Time' was inaugurated to facilitate railroad travel."

At the meeting on Electrophysics and Dielectrics, which was held under the guidance of Vladimir Karapetoff, four papers were presented, the most interesting of which, perhaps, was that by J. J. Torok of the Westinghouse Electric and Mfg. Co. on the Surge Impulse Breakdown of Air.

The other three papers presented at the electrophysics session consisted of one on the Influence of Internal Vacua and Ionization on the Life of Paper Insulated Cables, and two of a distinctly mathematical nature which, although of interest to the electrical engineer, will not be discussed here.

An extremely interesting event was the lecture on Monday evening on the Earth's Electric Charge, by Dr. W. F. G. Swann, director of the Bartol Research Foundation of the Franklin Institute. This lecture was given in accordance with a custom established before the war, of presenting at the annual meeting a lecture on some subject related to electrical engineering but yet not strictly engineering as such.

At the session on Tuesday afternoon a group of three papers on miscellaneous subjects was presented: The Saturation Permeameter, by S. L. Gakhale; The Manufacture and Magnetic Properties of Compressed Powdered Permalloy, by Shackelton and Barber; and The Effect of Humidity on Dry Flashover Potential of Pin Type Insulators by Littleton and Shaner.

The high development of the theory of electrical machinery was reflected in the character of the papers presented at the Electrical Machinery Sessions. In a series of papers on Synchronous Machines, by Messrs. Doherty, Nickle, Alger, Park and Robertson, all of the General Electric Co., the remarkable agreement of calculated values with test data on machines was demonstrated.

Among the social and non-technical events of the convention were a smoker and entertainment on Tuesday, the presentation of the John Fritz and Edison Medals to Gen. John J. Carty and Wm. D. Coolidge, respectively, on Wednesday evening, and the annual dinner dance on Thursday. Opportunity was given the visiting members to visit many projects of engineering interest in the vicinity of New York.

New Model K Cyclone Hoist

THE NEW MODEL K CYCLONE hoist, manufactured by The Chisholm-Moore Mfg. Co., Cleveland, Ohio, is constructed on the same gyrating yoke principle found in the previous Cyclone model hoist manufactured by the same company.

Engineering improvements, however, are intended to give the new hoist a greater efficiency. Among the changes was the addition of anti-friction bearings at every rotating point.

Another important improvement is the long-life lift wheel, made of a new steel alloy. All parts are strictly interchangeable. As with the previous Cyclone model, the entire mechanism of the hoist is enclosed in a dust-proof, oil-tight frame.

Deep Water Station to Operate at 1200 Lb.

IT WAS ANNOUNCED a few weeks ago that Stevens & Wood, Inc., 120 Broadway, New York, had been given the contract for the engineering and construction of the new Deep Water Station to be jointly owned by the American Gas & Electric Co. and by the American Electric Power Corp.

At that time, it was thought, but not definitely settled, that this station would use 1200 lb. pressure. Announcement is now made that 1200 lb. pressure has been decided upon after careful study and that each of the two initial power turbines will be of the cross compound type, the steam being reheated in the boilers between the 12,000-kw., high pressure element and the 41,000-kw. low pressure element. The total temperature of the steam entering each of the elements will be 725 deg.

Stevens & Wood report that these two 53,000-kw. power units, together with a 12,000-kw. high pressure unit, the exhaust steam from which supplies process steam to the adjacent plant of the DuPont Co., have recently been ordered from the General Electric Co.

News Notes

PRELIMINARY ANNOUNCEMENT by the A. S. M. E. indicates that the spring meeting, to be held in Pittsburgh from May 14 to 17, promises to be a large and interesting one. Special sessions will be devoted to the iron and steel industry, the glass industry and others, while various divisions of the society such as Fuels, Power, Machine Shop Practice and Hydraulics Divisions will sponsor sessions. Another group of sessions centered around the Division of Applied Mechanics and the Special Research Committee of Mechanical Springs are expected to be of great interest to mechanical designers.

DANIEL KENNEDY, president of the Kennedy Valve Mfg. Co., Elmira, N. Y., died in his 80th year at Hot Springs, Ark., on January 14, after a short illness. Mr. Kennedy came to America from Ireland at the age of 17; his first business venture was in connection with the old Boston Dry Dock built in the Erie Basin, Brooklyn, N. Y., in 1877. In competition with other designs submitted for valve equipment for this project, those of Mr. Kennedy were chosen. The installation he designed is still functioning to the satisfaction of the engineers in charge. This project established the firm of Daniel Kennedy with a very small shop in New York City and during the succeeding years as the business increased, the plant was moved to Coxsackie, N. Y., where the name was changed to The Kennedy Valve Mfg. Co. Further extension required a second move in 1907 and a larger plant was built in Elmira, N. Y.

KING REFRACTORIES CO., INC., Buffalo, N. Y., announces the appointment of Edw. Rahm, Jr., as sales manager. Mr. Rahm was for some years connected with the Erie City Iron Works. The company has also appointed district sales representatives as follows: E. T. Wingate, 26 Adelaide St., W., Toronto, Canada, and F. W. Fowler, 1525 East 82nd St., Cleveland.

WILLIAM S. GOULD, president of the Fuel Engineering Co. of New York, died suddenly at his home at Upper Montclair on January 23, 1928. Born at Owosso, Michigan, January 28, 1865, Mr. Gould received his technical training at the University of Michigan. He was the founder of the Fuel Engineering Co. of New York and its president from 1907 until his death. He was a member of both the American Society for Testing Materials and the American Society of Mechanical Engineers.

CHUSE ENGINE AND MFG. CO., Mattoon, Ill., announces that its property, consisting of real estate, buildings, machinery and equipment was sold on December 29, 1928, the sale being confirmed by the Court on January 21, 1928. A reorganization of the old company has taken place under the name of the Mattoon Engine Works, Successor to Chuse Engine & Mfg. Co., with headquarters at 120 N. 14th St., Mattoon, Ill.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 W. 39th St., New York, announces that because of the success of the recent transcontinental tour, the society is planning to run a vacation sight-seeing tour on the Great Lakes in conjunction with the Regional Meeting at the Twin Cities, from August 20 to 29. The tour will begin at Buffalo on Monday, August 20, 1928, the total cost for the round trip being about $200. Complete information regarding it can be obtained from the headquarters of the A. S. M. E. at the above address.

W. H. NICHOLSON & Co., Wilkes-Barre, Pa., recently placed its agency for cities of Utica, Syracuse and Rochester and vicinity in the hands of Arthur E. Jones Co., 415 S. A. & K. Bldg., Syracuse, N. Y. The company has appointed the C. Keiser & Co., of 2010 Ravenswood Ave., Dayton, O., for its agents for the counties of Western Ohio.

THE BROWN INSTRUMENT CO., Philadelphia, Pa., for a long time has supplied its pressure gages, thermometers and more lately its flow meters in flush type circular cases. Now the company announces that it is furnishing the Brown Continuous Strip Chart instruments in flush type cases. These instruments include Pyrometers, CO_2 Meters, Tachometers and Resistance Thermometers and they can be supplied in single or multiple models capable of producing from 1 to 12 records on a chart. A new feature of the flush type continuous

recorder is an arrangement by which the recording mechanism can be drawn from the case at the front for inspection, after which it can be pushed back and locked firmly in position.

BOTFIELD REFRACTORIES Co., Philadelphia, Pa., announces the appointment of Ires Prosser as Southeastern representative with headquarters in Atlanta, Ga.

PEERLESS UNIT VENTILATION Co., INC., announces that it has moved its main office and factories to 718-734 Crescent Ave., Bridgeport, Conn.

THE DAMPNEY Co. of America, Hyde Park, Boston, Mass., announces that it will be represented in the Province of Quebec, Canada, by W. K. Davidson Co., 332 William St., Montreal.

ERIE BALL ENGINE Co., Pittsburgh, Pa., announces that Robert W. Bier took charge of its Chicago office, 1540 Monadnock Block, Chicago, Ill., on January 1, 1928.

AMERICAN ARCH Co., INC., New York City, announces that G. S. Carrick, formerly president and general manager of Carrick Engrg. Co. of Chicago, has been appointed general manager of its industrial department and will have full charge of matters relating to the company's furnace products.

ANNOUNCEMENT IS MADE of the formation of Leeds, Tozzer & Co., Inc., 75 West Street, New York, to act as manufacturers' representatives and machinery engineers. Edward L. Leeds, president of the company, was recently vice president and director of Niles, Bement Pond Co. Brent A. Tozzer, vice president, was recently New York manager and sales engineer of the Niles Tool Works Co. and Pratt & Whitney Co.

ANNOUNCEMENT is made by the Timken Roller Bearing Co., Canton, O., that an expenditure of four million dollars is to be devoted to increasing the production facilities of the company during the coming year. The greater part of this is to be expended at Canton where both the steel mills and the bearing manufacturing plant will be considerably enlarged.

ALLIS-CHALMERS MFG. Co., Milwaukee, Wis., has opened a new district sales office at Phoenix, Ariz., 308 Heard Bldg., in charge of J. B. Cooper, Manager. This office will cover Arizona, New Mexico and the northern part of the Republic of Mexico. The company has also opened a branch at 619 Frost National Bank Bldg., with Earle R. Hury in charge. Another office is being opened at Grand Rapids, Michigan, in the Weiss Service Bldg., in charge of G. C. Pulver.

ACCORDING TO A statement by Wm. F. Raber, vice-president and general manager of San Diego Consolidated Gas & Elect. Co., San Diego, Calif., the major item of expense in its large construction program for 1928 is the addition that will be made to Station "B." Here a new 25,000-kw. turbo-generator with its boilers and auxiliaries will be installed.

ANNOUNCEMENT IS MADE by H. P. Davis, vice-president of Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa., of five promotions in the executive staff of its manufacturing department. W. J. Longmore has been transferred from the office of general purchasing agent to consulting supervisor of purchases; E. R. Norris, from director of works equipment to general works manager of all manufacturing operations; A. W. Bass, from director of works records and statistics to assistant to the vice-president; S. E. Marks, from director of traffic and shipping to director of traffic; C. G. Taylor from director of purchases to general purchasing agent.

ORTON CRANE & SHOVEL Co., 608 S. Dearborn St., Chicago, announces that Herbert Mertz, formerly secretary and sales manager, has resigned and will establish an office in New York to sell the company's products in New York and New England. P. A. Orton, Jr., becomes secretary and sales manager of the company.

GENERAL ELECTRIC Co., Schenectady, N. Y., announces that H. F. T. Erben, assistant vice president of the company, retired on January 1, 1928, after more than 40 yr. of service with the company. It also announces that B. L. Delack has been appointed manager of the Schenectady plant as of January 1, 1928, and E. A. Wagner has been appointed manager of the Pittsfield plant of the General Electric Co. Sales organization changes include the appointment of C. N. Gregory as manager of the New Haven, Conn., office succeeding Frederic Cutts; R. B. Ransom has been appointed resident agent in charge of the Hartford office, succeeding Mr. Gregory.

CONSOER, OLDER & QUINLAN, consulting engineers, 140 S. Dearborn St., Chicago, announce that on January 23, 1928, George B. Mulloy, formerly with Armour and Co., joined their organization in charge of a new department of industrial engineering.

ROSEVILLE WATER Co., of Placer County, Calif., is the latest utility property acquired by Public Utilities Consolidated Corp. (Arizona), a utility holding company controlled and managed by W. B. Foshay Co. The city of Roseville is a railroad junction and center of a large fruit and stock raising district and contains one of the largest ice and cold storage plants in the United States, owned by the Pacific Fruit Express Co.

HARVARD BUSINESS SCHOOL has just announced a special session for business executives to be given at the school during the coming summer. Among other interesting courses is one on public utility management and economics to be given by Professor Philip Cabot and D. W. Malott. Further information regarding these courses can be obtained from the secretary of Harvard University, 1 University Hall, Cambridge, Mass.

THE GREAT WESTERN POWER Co. of California, a subsidiary of The North American Co., announces the acquisition of 35 acres of land in San Francisco as a site for a new steam plant.

Initial capacity of this plant will be 35,000 kw. and it will be designed to burn oil as fuel. The plant will be equipped with 450-lb. boilers and will deliver electrical energy at 60 cycles, 11,000 v. It will double the company's present reserve steam supply for the San Francisco Bay region and will provide emergency service for the Great Western's extensive hydroelectric supply in this area.

Work is to start at once with completion expected next year. The building of this power house is in line with the company's policy of anticipating the rapid growth in electric load in the Bay region.

McClellan & Junkersfield, Inc., of New York, N. Y., have been engaged to design and supervise construction of this station.

AT THE MEETING of the Chicago Association of Consulting Engineers held at the City Club, Chicago, Ill., on the evening of January 16, the annual election of officers was held. The present officers were re-elected for the ensuing year and are as follows: Irving E. Brooke, president; Ernest V. Lippe, vice president; Rollo E. Gilmore, secretary-treasurer. This is the beginning of the eighth year since the association was organized. A year book of the association will be sent to those interested on application to the secretary at 104 S. Michigan Ave., Room 1619, Chicago, Ill.

CALIFORNIA RAILROAD COMMISSION has approved the purchase of Santa Cruz County Utilities of Boulder Creek by Public Utilities California Corp., a subsidiary of Public Utilities Consolidated Corp., the latter being the utility holding company of W. B. Foshay Co.

Catalog Notes

THE NEW GLOBACK JOINTS for high pressure piping are shown in a folder sent out by the Midwest Piping & Supply Co., 1450 S. Second St., St. Louis, Mo.

THE LATEST EDITION of the Weather Vein, published by Carrier Engineering Co. of Newark, N. J., contains detailed discussion of the development of the Paramount News Reel Service and of the part played by manufactured weather in its film laboratories.

THE ESTERLINE-ANGUS CO., Indianapolis, Ind., in an eight-page bulletin, No. 1127, illustrates and describes the new Esterline-Angus time recorder designed for many applications in both power plant and industrial process work.

CHICAGO PUMP CO., 2300 Wolfram St., Chicago, Ill., in Bulletin 137, describes and illustrates the Condo-Vac vacuum condensation pump.

DATA SHEET 101, issued by Bernitz Furnace Appliance Co., 80 Federal St., Boston, Mass., describes the Bernitz type S-79 ventilated furnace floor.

MANZEL BROTHERS CO., 309 Babcock St., Buffalo, N. Y., in Catalog 82, describes Model 82 force feed lubricators for Diesel engines, also for gas, oil, gasoline, steam engines and other machinery.

DEBOTHEZAT IMPELLER CO., INC., 1922 Park Ave., New York, N. Y., in a 24-page illustrated bulletin describes DeBothezat Disc Pressure Fans.

YARNALL-WARING CO., Philadelphia, Pa., in a 4-page leaflet, shows the Yarway floatless Hi-Lo alarm water column equipped with Yarway Sesure inclined water gage.

FLEXITALLIC GASKET CO., Camden, N. J., is issuing a folder giving complete information for ordering Flexitallic gaskets for pipe flanges, tube caps and manholes.

AMONG VARIOUS NEW BULLETINS recently received from the General Electric Co., Schenectady, N. Y., the following will be of interest to many of our readers: GEA-903, on Demand Meters; GEA-732A, D. & W. Oil Fuse Cutouts; GEA-439A, A Short Cut to the Solution of Floodlighting Problems; GEA-572, Automatic Switching Equipment; GEA-Type GTE Motors for Gearless Traction Elevators; GEA-875A, Type WD-300A Arc Welders; GEA-570A, Hand Starting Compensators; GEA-61A, Constant Speed Direct Current Motors; GEA-858, Low Speed Direct Current Generators; GEA-529A, Low Speed Synchronous; GEA-748A, Outdoor Station Equipment, Bus Supports for Outdoor Service; GEA-189A, Automatic Switching Equipments.

BLAW-KNOX CO., Pittsburgh, Pa., has issued a bulletin describing Security steel grating and flooring. This is made by welding twisted bars across the top of the bearing bars. The company is also issuing bulletin No. 1022, describing regenerative air preheaters for boilers.

WORTHINGTON PUMP & MACHINERY CORP., 115 Broadway, New York, N. Y., has issued a bulletin describing horizontal triplex power pumps of the totally enclosed, semi-portable, outside-packed plunger type.

STEPHENSON MFG. CO. of Albany, N. Y., is issuing two new circulars. One is for dealers showing the basis on which the company's product is distributed. The other gives facts for users about bar belt dressing, its qualities and results obtained. Copies may be obtained by writing direct to the company.

THE CHAPMAN VALVE MFG. CO., Indian Orchard, Mass., is issuing a folder describing the improved Chapman motor unit for electrical operation of valves, sluice gates and the like.

STEAM JET AIR pumps are completely described and illustrated in bulletin 116-B, recently issued by Foster Wheeler Corp., 165 Broadway, New York, N. Y.

PRAT-DANIEL CORP., 101 Park Ave., New York, N. Y., has just issued a folder describing the Type 1-A stream line stack, and another describing the Types 2, 2-A and 3 stream line stacks.

INGERSOLL-RAND CO., 11 Broadway, New York, is sending out an illustrated bulletin describing the oil electric locomotive manufactured by General Electric Co., American Locomotive Co. and Ingersoll-Rand Co.

HOMESTEAD VALVE MANUFACTURING CO., INC., Homestead, Pa., in a recent bulletin describes Hypressure Jenny. This is a device intended to generate steam quickly at 150-lb. pressure and to carry along with the steam a cleaning solution. The equipment has found application in cleaning machinery and building, removing paint and many other applications.

FAIRBANKS, MORSE & CO., 900 S. Wabash Ave., Chicago, Ill., in recent bulletins describes mine gathering pumps of the enclosed drive, self-oiling type, and the Fig. 850 centrifugal pumps of ball bearing moderate head, single-stage, double-suction type. In bulletin H341A are described sewage and trash pumps of both vertical and horizontal design.

C. H. WHEELER MFG. CO., 19th St., Lehigh and Sedgley Ave., Philadelphia, Pa., in a 4-page leaflet gives details of the Leach fracto condenser and heat exchanger.

ATWOOD NON-RETURN VALVES for 400, 600 and 900 lb. working pressure and 750 deg. total temperature are described in a leaflet issued by the Pittsburgh Valve, Foundry & Construction Co.

Power Plant Construction News

Ark., Camden—The Arkansas Power & Light Co., Little Rock, Ark., is planning the construction of a transmission line from Pine Bluff to Camden, to operate at 110,000 volts.

Ark., Salem—North Arkansas Power Co., Mountain Home, Ark., Wyatt Wolf, head, is reported planning the installation of an electric light and power plant for local commercial service. A franchise has been granted. The construction of a one-story ice-manufacturing plant is also under consideration.

Ark., Smackover—The Weston Oil Corporation, Smackover, is planning the purchase of gas engine equipment, belting and other apparatus for service at its local properties.

Calif., Auburn—The Board of Directors, Auburn Fruit Exchange, is considering the construction of a new ice and precooling plant, estimated to cost about $100,000 with equipment.

Calif., Long Beach—The Bowering Soap Co., care of C. P. Hubert, 1210 West Sixty-eighth Street, Los Angeles, Calif., architect, is said to be planning the construction of a boiler plant in connection with a new factory group on local site, entire project to cost in excess of $500,000 with equipment.

Calif., San Francisco—The Northwestern Pacific Railroad Co., San Francisco, is considering the construction of a power house at its shops in this section, reported to cost in excess of $50,000 with equipment.

Colo., Brighton—The Common Council is planning the installation of electric-operated pumping equipment and auxiliary machinery in connection with extensions and improvements in the municipal waterworks. Douglass & Thwaits, Continental Oil Building, Denver, Colo., are engineers.

Conn., Stamford—Richards & Co., Inc., manufacturer of chemicals, etc., will proceed with superstructure for a new one-story boiler plant, 80 x 100 ft., in connection with a general expansion program to cost about $90,000.

Ga., Alma—The Southeast Georgia Power Co., Douglas, Ga., has authorized the installation of additional equipment at its local steam-operated electric power plant, including Diesel engine unit.

Ga., Dallas—The Alabama Water Service Co., Birmingham, Ala., plans the installation of additional equipment at local plant of the Dallas Electric Co., a subsidiary organization, including two 200 kv.a. generating units and accessories.

Ill., Aurora—The Chicago, Burlington & Quincy Railroad Co., 547 West Jackson Boulevard, Chicago, Ill., is said to be planning the installation of a water-treating plant at its local shops.

Ill., Centralia—The City Council is considering the construction of a municipal electric light and power plant. An engineer will be selected in the near future to prepare plans and make estimates of cost.

Ill., Chicago—The Commonwealth Edison Co., 72 West Adams Street, has plans maturing for a one-story and basement addition to its power substation at 2125 South Marshfield Street.

Iowa, Buffalo—The Davenport Cement Co., Davenport, Iowa, J. R. Lane, president, is reported planning the construction of a boiler and power house at its proposed local mill. Bids will be asked early in the spring. The entire project will cost in excess of $1,000,000.

Iowa, Dubuque—The Key City Gas Co., Dubuque, is considering the construction of an addition to its gas-generating plant, reported to cost more than $200,000 with equipment.

Iowa, Nevada—The Iowa Railway & Light Co., Cedar Rapids, Iowa, has plans for an addition to its power plant on local site, including installation of 750-hp. engine unit and other equipment, reported to cost about $35,000.

Md., Amcelle—The Celluloid Corporation, operated by the Celanese Corporation, Amcelle, is planning the construction of a boiler plant at its proposed local plant. The entire project will cost more than $1,000,000. Bids will be asked at once.

Mass., Brockton—The Brockton Gas Light Co. is arranging the early erection of a proposed addition to its boiler plant, 35 by 50 ft., to cost in excess of $100,000 with equipment. The Charles H. Tenney Co., 200 Devonshire Street, Boston, Mass., is engineer.

Miss., Aberdeen—S. R. Morgan & Co., Rector Building, Little Rock, Ark., has purchased a local site and plans the construction of a one-story ice-manufacturing plant with initial equipment for a capacity of 40 tons per day, estimated to cost about $100,000.

Mo., St. Louis—The Alois Aufrichtag Copper & Sheet Iron Mfg. Co., 900 South Third Street, has filed plans for a one-story boiler plant at its proposed new mill on Delor Street. The entire project will cost in excess of $100,000.

Neb., Omaha—It has been reported that Swift & Co. are planning the addition of three new 800-hp. boilers and pulverized coal equipment.

N. J., Pitman—The Riley Milk & Ice Co., Pitman is planning the construction of a new cold storage and refrigerating plant, reported to cost about $100,000, with equipment.

N. D., Grand Forks—The Great Northern Railway Co., St. Paul, Minn., is said to be planning the complete electrification of its local locomotive repair shops in connection with extensions in engine house and terminal. The entire program will cost in excess of $500,000.

N. D., Hettinger—The Dakota Public Service Co. is planning extensions and improvements in power plant in this section, including installation of new generating unit and auxiliary equipment for service at Hettinger, Reeder and vicinity.

N. D., Kenmare—M. A. Erickson, operating the Rugby Light & Power Co., Rugby, N. D., is at the head of a project to construct a steam-operated electric power plant on local site, estimated to cost about $75,000 with equipment. It is proposed to begin work in the spring.

Ohio, Canton—The Timken Roller Bearing Co., Canton, plans the construction of a power substation for service at its plant. The work will be carried out in connection with new plant units, entire project to cost more than $1,000,000.

Ohio, Cleveland—The American Steel & Wire Co., Rockefeller Building, will install electric power equipment in connection with proposed extensions to its Cuyahoga works, including a new rod mill. Entire project will cost about $3,000,000.

Okla., Sapulpa—The Sapulpa Refining Co. plans the installation of boilers and other power equipment, tanks, etc., in connection with proposed rebuilding of its oil refinery recently destroyed by fire with loss reported in excess of $200,000.

Pa., Philadelphia—The Pennsylvania Salt Mfg. Co., Widener Building, has filed plans for a one-story engine house at its plant, Delaware and Shunk Streets, estimated to cost $45,000, with equipment.

S. C., Taylors—The Piedmont Print Works, Taylors, has approved plans for the construction of a one-story boiler plant at its proposed local textile dye and print mill. The entire project will cost in excess of $90,000 with equipment. J. E. Sirrine & Co., Greeneville, S. C., are engineers.

Texas, Arlington—The Southern Ornamental Iron Works, 2425 South Horwood Street, Dallas, Texas, is said to be planning the construction of a boiler house at its proposed new local plant. Entire project will cost in excess of $200,000.

Texas, Abernathy—The Abernathy Gin Co. plans the construction of a boiler plant in connection with proposed rebuilding of its cotton-ginning works, recently destroyed by fire. The project will cost close to $30,000. C. J. Felmet is manager.

Va., Stanley—The Stanley Milling Co. plans the installation of boilers and other power equipment in connection with rebuilding of portion of grain and flour mill recently destroyed by fire with loss of about $150,000.

Wash., Auburn—The Ice Delivery Co., 115 Bell Street, Seattle, Wash., has plans under way for a one-story ice-manufacturing plant on local site, reported to cost about $35,000, with equipment.

Wis., Marion—The Common Council is considering the installation of pumping machinery and auxiliary equipment in connection with a proposed municipal waterworks. Entire project will cost about $65,000. McMahon Engineering Co., Menasha, Wis., is engineer.